CryoVEx08/09-Antarctica
Data Acquisition and Final Processing Report

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1. Introduction

Following the successful 2004, 2005, 2006 and 2007 campaigns, this document reports the data acquisition of the CryoVEx08/09-Antarctica campaign which was carried out in Dronning Maud Land from November 11^{th}, 2008 to February 11^{th}, 2009. The airborne part of the campaign was successfully carried out by the Alfred Wegener Institute (AWI) using the AWI POLAR 5 (Basler BT-67) aircraft, whereas the GPS ground measurements were carried out by TU Dresden.

The CryoSat validation activities undertaken during 2004, 2005, 2006, 2007 involved simultaneous radar altimetry and laser data acquisition over land ice and sea ice sites in the Arctic. Ground-based land ice measurement activities were carried out to characterize surface and subsurface snow and ice conditions.

The CryoVEx08/09-Antarctica campaign took place for the second time, after last years AWI-test campaign, in Antarctica with POLAR5. Airborne and ground measurements were recorded in this campaign, which was the first CryoSat CalVal experiment supported by ESA in Antarctica. Both, airborne and ground measurements were recorded mainly in the blue ice region close to Novolazarevskaya-Airbase and were carried out by scientists from AWI and TU Dresden.

The key objective of the campaign is a better approximation of the error range of the elevation obtained from SAR-processed altimetric radar returns and its sensitivity to surface roughness. Therefore a combination of airborne SAR and precise kinematic GPS measurements in blue ice was chosen to be the best opportunity to fulfill the scientific objectives. Furthermore, a specific setup of the survey, to measure a narrow grid, was chosen for the first time in the CryoVEx history.

In general, the airborne and ground activities were very successful. All planned survey lines, including the survey grid, were measured and some additional data could be collected (e.g. flight lines at Potsdam glacier as well as some lines over ice shelf and the accumulation area close to the German overwintering station Neumayer).

This report outlines the field operations and the data collected by AWI and TU Dresden during the CryoVEx08/09-Antarctica campaign. In addition a few examples of preliminary processed data as well as some preliminary results of the laser scanner data and of the kinematic GPS ground data will be shown.

2. Airborne operations

2.1. Summary of the Aircraft operations

After successful installation of the ASIRAS and laser scanner system in the Basler BT-67 aircraft, the system was tested in Bremerhaven on October 19^{th} 2008. During these flights different setups of the ASIRAS instrument were successfully tested by technicians of RST, FILAX and AWI. After a quick data analysis through AWI and RST engineers and disintegration of the measurement system POLAR 5 went down to Antarctica, ready for operation in Dronning Maud Land (DML).
The scientific crew arrived at Neumayer station at November 18^{th}. Here the system was integrated into POLAR5. Ground tests and the first test flight toke place close to Neumayer station. After successful completion of the data quality check and data backup POLAR5 went to Novolazarevskaya Airbase to continue the planned CryoVEx measurement flights. Table 2.1 gives an overview of the flight activity in chronological order and below a short day-to-day description is found.

Table 2.1.: Overview of flight activity

Day	Date	Activity	flight hours
	2008-10-19	Bremerhaven test flight, runway (RW) and corner reflector (CR) passes	1.2h
	2008-11	Ferry: Bremerhaven ⇒ Neumayer	
1	2008-12-18	Arrival of science crew at Neumayer	
2 to 4	2008-12-19 to 2008-12-20	Integration of system at POLAR 5 Office installation, Computer and ASIRAS ground check	
5	2008-12-21	Neumayer test flight including RW and open ocean survey in different altitudes and modes, ALS test	3.2h
6	2008-12-22	Ferry: Neumayer ⇒ Novo, data acquisition in LAMA	4.7h
7 to 8	2008-12-23 to 2008-12-24	No flights, due to ALS ground tests. Office installation. Backup of new data and test flight	
9	2008-12-25	Novo, LAMA flights on site (CryoSat tracks, RW, CR). Start of data backup.	6.3h
10	2008-12-26	No flights, due to data backup quality check and ALS ground test.	
11	2008-12-27	Novo, LAMA flights on site (repeat of CR and CryoSat tracks, Grid and lines over Potsdam glacier)	7.5h
12 18	2008-12-28 2009-01-03	Data backup and data quality check as well as preliminary processing.	
19	2009-01-04	Ferry: Novo ⇒ Neumayer, data acquisition in HAM and LAMA	4.2h
20	2009-01-05	Data backup and disintegration of ASIRAS system at POLAR 5.	
Total		Flight hours for Antarctica campaign only	26h

Date	Activity
October 18:	Integration of system in POLAR 5 and ground checks. Installation of a corner reflectors at the end of Bremerhaven runway.
October 19:	Test flight over North Sea and around Bremerhaven Airport to check different ASIRAS modes and fixed laser scanner (ALS). Additional to this program some corner reflector passes could be carried out.
November:	Transfer of aircraft from Bremerhaven to Neumayer (Antarctica).
November - December:	DROMLAN flights.
December 18:	Arrival of science crew at Neumayer station. Unloading of freight and installation of office workplace and first computer tests.
December 19-20:	Integration of system at POLAR 5 and ground tests. Test of pre-processing and backup software at office. Briefing with whole flight crew and fixing of the flight schedule.
December 21:	Test flight over open ocean in different altitudes and acquisition modes. Additional some lines over Soerasen and Halfvaryggen as well as shelf ice were carried out. Problems with laser scanner - no data for whole test flight. Backup and quality check of of new ASIRAS data.
December 22:	ALS ground test - successful completion. Afternoon ferry flight from Neumayer to Novo airbase. Flight altitude varied between 300 m to 600 m aboth ground (LAMA). Partly ALS data loss due to bad reflectivity, file size limitation issue of acquisition system and maybe temperature issues. Different ALS settings were used (scan angle step, points per line, scans per second - ALS SP worked with different configurations). Problem: New ALS source measures only up to 300 m and shows at some points data loss. One of the Novatel GPS receivers didn't record, due to a hard disk error - no data recovery possible.
December 23-24:	Novo, installation of office and CR at Novo runway. Backup and data quality check. Briefing with TU-Dresden scientists, fixing the final flight schedule. ALS ground tests.
December 25:	Novo, LAMA measuring flights at 300 m and partly at 600 m above ground. CryoSat tracks, CR and runway crossing were carried out. ALS in the beginning showed bad quality, maybe temperature too low. After approx. 1h high ALS quality signal was recorded. Partly data loss due to cloud cover. Problems with precise navigation and so hit of CR, despite repeat passes. Video was not fully recording, due to a unknown system problem. Evening start of data backup and quality control. ALS showed a general data loss (missing lines) of approx. 60%.

continued

Date	Activity
December 26:	Data backup. ALS ground check (laser source is working, connections tied, ALS connection with hyper terminal - communication: ok. Basis setting: ok. Internal memory buffer size of ALS is only 20% of value given in manual. This might be the reason for the data loss. No way to increase the buffer size - RIEGL problem. Decision to continue flight program the next day.
December 27:	Novo, LAMA measuring flights at 300 m. Repeat of CryoSat lines, CR passes and completion of survey grid. Again problems with precise navigation and CR hits. Additional lines acquired over Potsdam glacier (accumulation zone). Successful completion of whole measurement program.
December 28 - January 3:	Data backup, data quality check and preliminary processing of ASIRAS and ALS data. ALS data is usable and shows good quality despite data loss.
January 4:	Ferry flight from Novo to Neumayer. This was used for HAM acquisitions 2500 m above ground for interferometric phase studies. LAMA repeat flight of one line over Halfvaryggen, shelf ice and HAM acquisition over open water.
January 5-6:	Data backup and disintegration of ASIRAS system at POLAR 5.

2.1.1. Instrument installation

The POLAR5 was equipped with the ASIRAS instrument, a laser scanner, a single beam laser, two 1 Hz Trimble GPS receivers, two 20 Hz Novatel GPS receiver, a video camera and an INS platform. Their positions within the aircraft reference frame is given in Table 2.3 and Figure 2.1 sketches the instrument installation in the aircraft.

Table 2.3.: Instrument installation in the POLAR 5 reference frame. Origin of the system is (middle of aircraft pilot door, floor) the INS. All instruments where measured to its phase center within an accuracy of ±5 cm. Offset definition: x positive to the front, y positive to the right wing and z positive down.

Instrument	dx (m)	dy (m)	dz (m)
INS gyros	+0.20	+0.60	-0.75
GPS-rear	-5.74	0.00	-2.03
GPS-front	-0.80	0.00	-2.06
Novatel receiver	TBD	TBD	TBD
ASIRAS center	-7.68	0.00	+0.55
ASIRAS Panel 1	-7.68	-0.38	+0.55
ASIRAS Panel 2	-7.68	+0.38	+0.55
Laser scanner	-8.03	+0.35	+0.18
Laser altimeter	-8.68	+0.38	+0.37
Video camera	TBD	TBD	TBD

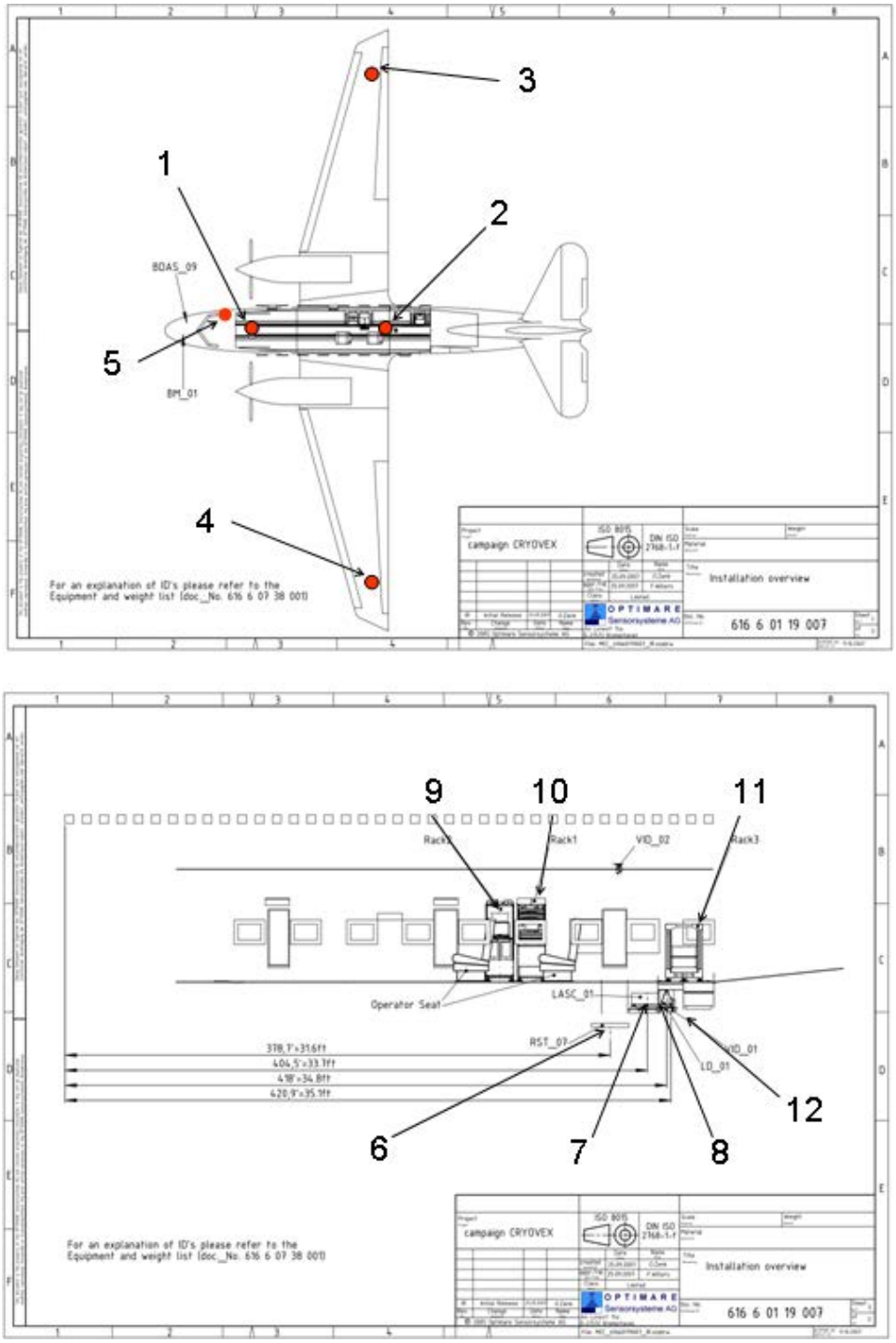


Figure 2.1.: Sketch of POLAR 5 aircraft showing positions of measuring devices
1+2 front, rear GPS antenna (Trimble receiver)
3+4 right, left GPS antenna (Novatel receiver)
5 INS
6 RST ASIRAS antenna
7 RIEGL laser scanner (LMSQ-280)
8 RIEGL laser altimeter (LD90) 9 Rack II (ASIRAS)
10 Rack I (Basis navigation)
11 Rack III (Video and ALS sensor processor)
12 Dallmaier video camera

2.2. Recorded airborne data

2.2.1. GPS

Kinematic GPS is the key positioning method of the aircraft. GPS dual-frequency phase data were logged at 1 Hz and 20 Hz using one Trimble and one Novatel ground base receiver as reference site, and four aircraft receivers. The ground base stations were installed at Novolazarevskaya Airbase. The two Trimble 4000SSI aircraft receivers logged at 1 Hz and the two Novatel logged at 20 Hz. Both the time server of the airborne system and the ASIRAS instrument were triggered by the PPS-pulse of one of the Trimble receivers. Data were logged in the receivers during flights and downloaded upon landing on laptop PC's. All Trimble data were recovered and a preliminary kinematic GPS processing was performed after downloading (see Table 2.4). Data of the high data rate Novatel receiver will be used for comparison to the Trimble solutions at a later processing state.

Table 2.4.: Preliminary processed GPS files in ESA binary format.

Date	Filename	Start time (SOD)	Stop time (SOD)	Filesize (Mb)
2008-10-19	GPS_F_01_20081019T105522_120725	39322	43645	0.3
2008-12-21	GPS_F_01_20081221T182156_213431	66116	77671	0.7
2008-12-22	GPS_F_01_20081222T200337_244213	72217	88933	1.0
2008-12-25	GPS_F_01_20081225T150832_212648	54512	77208	1.4
2008-12-27	GPS_F_01_20081227T102247_175327	37367	64407	1.6
2009-01-04	GPS_F_01_20090104T083257_124215	30777	45735	0.9
2008-12-21	GPS_R_01_20081221T182418_213435	66258	77675	0.7
2008-12-22	GPS_R_01_20081222T200534_244226	72334	88946	1.0
2008-12-25	GPS_R_01_20081225T150832_212648	54512	77208	1.4
2008-12-27	GPS_R_01_20081227T102334_175339	37414	64419	1.6

2.2.2. INS

A Honeywell inertial navigation system was used throughout the surveys to record inertially integrated position, velocity and attitude information. Data were logged on the Medusa_P data base and downloaded after each flight. Data from all flights have been stored and transferred to the ESA binary format (see Table 2.5).

Table 2.5.: Preliminary processed INS files in ESA binary format.

Date	Filename	Start time (SOD)	Stop time (SOD)	Filesize (Mb)
2008-10-19	INS_20081019T093324_120617	34404	43577	78.9
2008-12-21	INS_20081221T183305_213436	66785	77676	93.7
2008-12-22	INS_20081222T201414_244123	72854	88883	137.9
2008-12-25	INS_20081225T151947_212623	55187	77183	189.2
2008-12-27	INS_20081227T103824_175212	38304	64332	223.8
2009-01-04	INS_20090104T084636_124200	31596	45720	121.5

2.2.3. Laser scanner

A Riegl laser scanner (LMS-Q280) was used to measure the range between the aircraft and the snow or ice surface. The laser scanner data were logged in binary format on the Medusa_P data base and downloaded after each flight. The files are time tagged by the GPS PPS signal. A separate ASCII file including these time tags was produced during flight. Each time a PPS reaches the instrument an internal time counter is set to zero. During post processing both the data file and the time file are combined, giving GPS (UTC-time) based range information. Table 2.6 shows the preliminary processed laser scanner files of the campaign. The nominal data-logging rate is 80 scans/second; each scan consists of 113 single laser shots. At approx. 700 m above ground this corresponds to a 500 m wide swath, with a point spacing of 4.4 m across and 0.8 m along track. During flight a real time quality control showed rather frequently a missing scan line (approx. 1 out of 80 scans), however this has only minor affect to the data quality.

Table 2.6.: Preliminary processed ALS files in ESA binary format.

Date	Filename	Start time (SOD)	Stop time (SOD)	Filesize (Mb)
2008-12-22	ALS_L1B_20081222T201745_201748	73065	73068	0.3
2008-12-22	ALS_L1B_20081222T202619_204243	73579	74563	66.1
2008-12-22	ALS_L1B_20081222T204746_204809	74866	74889	1.5
2008-12-22	ALS_L1B_20081222T205202_235958	75122	86398	762.6
2008-12-25	ALS_L1B_20081225T152253_152347	55373	55427	5.9
2008-12-25	ALS_L1B_20081225T154307_154710	56587	56830	31.3
2008-12-25	ALS_L1B_20081225T154846_160253	56926	57773	114.2
2008-12-25	ALS_L1B_20081225T160355_160632	57835	57992	14.0
2008-12-25	ALS_L1B_20081225T160809_161259	58089	58379	47.1
2008-12-25	ALS_L1B_20081225T172156_172252	62516	62572	9.2
2008-12-25	ALS_L1B_20081225T172451_175040	62691	64240	212.9
2008-12-25	ALS_L1B_20081225T175408_175654	64448	64614	23.2
2008-12-25	ALS_L1B_20081225T175936_203620	64776	74180	1276.8
2008-12-25	ALS_L1B_20081225T204325_211936	74605	76776	285.9
2008-12-27	ALS_L1B_20081227T105156_105252	39116	39172	8.0
2008-12-27	ALS_L1B_20081227T110023_110119	39623	39679	8.0
2008-12-27	ALS_L1B_20081227T112436_112855	41076	41335	36.4
2008-12-27	ALS_L1B_20081227T113316_114247	41596	42167	85.7
2008-12-27	ALS_L1B_20081227T125431_151947	46471	55187	1210.0
2008-12-27	ALS_L1B_20081227T152018_172426	55218	62666	1018.4
2008-12-27	ALS_L1B_20081227T172638_173837	62798	63517	72.7
2009-01-04	ALS_L1B_20090104T111312_111514	40392	40514	13.2
2009-01-04	ALS_L1B_20090104T111624_121926	40584	44366	482.3

2.2.4. ASIRAS

The ASIRAS system was run as tested during the test flight on October 19, 2008. The system was timed using a 1 PPS signal and an ASCII datation string from the Trimble GPS receiver.

Extensive tests and data backup of the upgraded system were performed during the first test flights. Additional to the normal operation of the system in LAM or HAM mode the new LAMA was used. After each take off the calibration mode (CAL2) was carried out. Calibration, log and data files were

transferred from the data PC's to the hard disk for backup after flights. The data were then stored on magnetic tapes and on hard disks.

Most of the ASIRAS data were obtained in the LAMA mode at 25 MHz. Data were acquired continuously over the main sites. In Table 2.7 all ASIRAS log files are listed, together with the start and stop acquisition time and some additional information. The CryoSat validation profiles are highlighted in red.

Table 2.7.: Recorded ASIRAS log files. CryoSat validation lines are highlighted in red, the profiles corresponding to the grid in blue. Abbreviations for operation mode and surface types:
A-Any
OW-Open water
BI-Blue Ice
GL-Glacier
X-Cracks, Crevices
MO-Morraine
IS-Ice Sheet
IE-Ice egde
SI-Sea Ice
SH-Shelf Ice
CR-Corner reflector
RW-runway
HG-Hangar
HAMO4000 High Altitude Mode 4000Hz - original configuration
LAMO2500 Low altitude mode (2500 Hz PRF) original LAM
LAMA2000 LOW ALTITUDE MODE A (2000 KHZ PRF)
LAMA2500 LOW ALTITUDE MODE A (2500 KHZ PRF)
LAMA3000 LOW ALTITUDE MODE A (3000 KHZ PRF)

Logfile	Operation Mode	Initial frequency (MHz)	Surface type	Start time (UTC)	Start time (SOD)	Stop time (UTC)	Stop time (SOD)	Acquis. time (s)	Remark
A081221_00	LAMO2500	20	OW	18:53:19	67999	18:55:12	68112	113.319	
A081221_01	LAMA2500	25	OW	18:55:52	68152	18:58:00	68280	128.214	
A081221_02	LAMA2500	50	OW	19:00:43	68443	19:02:10	68530	87.111	
A081221_03	LAMO2500	60	OW	19:05:43	68743	19:07:18	68838	95.045	
A081221_04	LAMA2500	60	OW	19:07:42	68862	19:09:11	68951	89.005	
A081221_05	LAMA2500	75	OW	19:11:12	69072	19:12:36	69156	84.072	
A081221_06	LAMO2500	80	OW	19:13:08	69188	19:14:42	69282	94.021	
A081221_07	LAMO2500	80	OW	19:15:10	69310	19:16:09	69369	59.078	
A081221_08	LAMA2500	50	OW, IE, SH	19:20:21	69621	19:24:44	69884	263.998	
A081221_09	LAMA2500	50	IS	19:58:51	71931	20:09:47	72587	656.061	DML94-95
continued									

Logfile	Operation Mode	Initial frequency (MHz)	Surface type	Start time (UTC)	Start time (SOD)	Stop time (UTC)	Stop time (SOD)	Acquis. time (s)	Remark
A081221_10	LAMA2500	50	IS	20:09:51	72591	20:10:22	72622	31.044	
A081221_11	LAMA2500	50	IS	20:13:48	72828	20:42:52	74572	1744.941	DML95-97
A081221_12	LAMA2500	50	IS	20:46:18	74778	21:06:08	75968	1190.958	DML97-96
A081222_00	LAMA2500	50	IS	20:40:29	74429	20:45:30	74730	301.159	
A081222_01	LAMA2500	50	IS	20:46:26	74786	21:13:53	76433	1647.114	DML96-97
A081222_02	LAMA2500	50	IS	21:17:40	76660	21:22:48	76968	308.235	
A081222_03	LAMA2500	50	IS	21:22:56	76976	21:29:22	77362	386.284	
A081222_04	LAMA2500	35	IS	21:29:59	77399	21:39:27	77967	568.184	
A081222_05	LAMA2500	50	IS	21:39:49	77989	22:40:41	81641	3652.091	
A081222_06	LAMA2500	50	IS	22:42:08	81728	00:30:36	1836	6508.037	
A081225_00	LAMA2500	40	RW, CR, BI	15:41:12	56472	15:41:14	56474	2.199	
A081225_01	LAMA2500	25	RW, CR, BI	15:54:47	57287	15:56:00	57360	73.992	
A081225_02	LAMA2500	25	RW, CR, BI	16:00:24	57624	16:01:46	57706	82.050	
A081225_03	LAMA2500	25	RW, CR, BI	16:04:32	57872	16:06:01	57961	89.997	
A081225_04	LAMA2500	25	RW, CR, BI	16:10:13	58213	16:15:57	58557	344.030	
A081225_05	LAMA2500	25	BI	16:19:13	58753	16:23:15	58995	242.002	U20-P13
A081225_06	LAMA2500	50	BI	16:24:06	59046	16:27:51	59271	225.985	
A081225_07	LAMA2500	50	BI, CR	16:31:55	59515	16:45:39	60339	824.032	U14-U08
A081225_08	LAMA2500	25	BI	16:52:59	60779	17:02:07	61327	548.001	U08-E21
A081225_09	LAMA2500	25	BI, CR	17:09:37	61777	17:25:18	62718	941.980	CY3
A081225_10	LAMA2500	25	BI	17:28:55	62935	17:43:02	63782	846.996	CY2
A081225_11	LAMA2500	25	BI, CR	17:47:26	64046	18:02:35	64955	909.048	CY4
A081225_12	LAMA2500	25	BI	18:06:10	65170	18:21:54	66114	944.232	CY2
A081225_13	LAMA2500	25	BI, CR	18:27:21	66441	18:41:07	67267	826.008	CY4
A081225_14	LAMA2500	25	BI, CR	18:44:24	67464	19:00:24	68424	959.996	CY3
A081225_15	LAMA2500	25	BI	19:02:10	68530	19:14:59	69299	769.072	CY1
A081225_16	LAMA2500	25	BI, IS	19:24:38	69878	19:54:31	71671	1793.048	WP2-WP1
A081225_17	LAMA2500	25	IS	20:03:26	72206	20:18:30	73110	904.052	CY6
A081225_18	LAMA2500	25	IS	20:21:42	73302	20:37:21	74241	939.968	CY5
continued									

Logfile	Operation Mode	Initial frequency (MHz)	Surface type	Start time (UTC)	Start time (SOD)	Stop time (UTC)	Stop time (SOD)	Acquis. time (s)	Remark
A081225_19	LAMA2500	25	IS	20:38:59	74339	20:42:46	74566	227.067	CY7
A081225_20	LAMA2500	25	IS	20:50:32	75032	21:06:11	75971	939.965	CY7
A081225_21	LAMA2500	25	RW, CR, BI	21:08:53	76133	21:13:51	76431	298.016	
A081225_22	LAMA2500	25	RW, CR, BI	21:16:30	76590	21:18:36	76716	126.989	
A081227_00	LAMA2500	50	RW, CR, BI	11:29:40	41380	11:31:56	41516	136.219	
A081227_01	LAMA2500	50	BI	11:35:33	41733	11:44:51	42291	558.125	U20-P13
A081227_02	LAMA2500	25	BI, CR	11:50:49	42649	12:04:09	43449	800.107	U14-U08
A081227_03	LAMA2500	25	BI	12:10:11	43811	12:19:32	44372	561.077	E2
A081227_04	LAMA2500	25	BI, CR	12:22:39	44559	12:36:05	45365	806.063	CY4
A081227_05	LAMA2500	25	BI	12:40:55	45655	12:52:04	46324	669.324	E1
A081227_06	LAMA2500	25	BI, Grid	12:58:30	46710	13:06:05	47165	455.227	
A081227_07	LAMA2500	25	BI, Grid	13:10:06	47406	13:17:22	47842	436.102	
A081227_08	LAMA2500	25	BI, Grid	13:20:08	48008	13:28:24	48504	496.129	
A081227_09	LAMA2500	25	BI, Grid	13:32:35	48755	13:39:34	49174	419.261	
A081227_10	LAMA2500	25	BI, Grid	13:42:29	49349	13:51:03	49863	514.215	
A081227_11	LAMA2500	25	BI, Grid	13:54:26	50066	14:02:26	50546	480.194	
A081227_12	LAMA2500	25	BI, Grid	14:05:40	50740	14:13:49	51229	489.305	
A081227_13	LAMA2500	25	BI, Grid	14:17:28	51448	14:25:36	51936	488.206	
A081227_14	LAMA2500	25	BI, Grid	14:27:58	52078	14:35:38	52538	460.188	
A081227_15	LAMA2500	25	BI, Grid	14:39:12	52752	14:47:22	53242	490.199	
A081227_16	LAMA2500	25	BI, Grid	14:49:58	53398	14:57:26	53846	448.258	
A081227_17	LAMA2500	25	BI, Grid	15:00:31	54031	15:08:19	54499	468.234	
A081227_18	LAMA2500	25	BI, Grid	15:11:27	54687	15:19:20	55160	473.254	
A081227_19	LAMA2500	25	BI, Grid	15:22:27	55347	15:30:25	55825	478.209	
A081227_20	LAMA2500	25	BI, Grid	15:33:45	56025	15:44:49	56689	664.277	
A081227_21	LAMA2500	25	BI, Grid	15:48:02	56882	15:55:59	57359	477.221	
A081227_22	LAMA2500	25	BI, Grid	15:58:37	57517	16:06:57	58017	500.208	
A081227_23	LAMA2500	25	BI, Grid	16:10:00	58200	16:18:10	58690	490.226	
A081227_24	LAMA2500	25	BI, Grid	16:21:13	58873	16:28:10	59290	417.329	
continued									

Logfile	Operation Mode	Initial frequency (MHz)	Surface type	Start time (UTC)	Start time (SOD)	Stop time (UTC)	Stop time (SOD)	Acquis. time (s)	Remark
A081227_25	LAMA2500	25	BI, Grid	16:30:58	59458	16:38:57	59937	480.298	
A081227_26	LAMA2500	25	BI, Grid	16:43:25	60205	16:48:28	60508	303.338	
A081227_27	LAMA2500	25	BI, Grid	16:51:41	60701	16:56:50	61010	309.142	
A081227_28	LAMA2500	25	BI, Grid	16:59:20	61160	17:05:45	61545	385.229	
A081227_29	LAMA2500	25	BI, Grid	17:09:36	61776	17:14:17	62057	281.221	
A081227_30	LAMA2500	25	BI, Grid	17:17:58	62278	17:24:03	62643	365.284	
A081227_31	LAMA2500	25	BI, CR	17:25:15	62715	17:36:28	63388	673.013	
A090104_00	HAMO5000	/	IS	09:11:02	33062	09:12:21	33141	79.283	
A090104_01	HAMO5000	/	IS	09:13:47	33227	09:15:11	33311	84.049	
A090104_02	HAMO5000	/	IS	09:16:01	33361	09:17:32	33452	92.086	
A090104_03	HAMO5000	/	IS	09:18:15	33495	09:25:29	33929	434.296	
A090104_04	HAMO5000	/	IS	09:26:11	33971	09:27:25	34045	74.065	
A090104_05	HAMO5000	/	IS	09:29:44	34184	09:30:50	34250	66.047	
A090104_06	HAMO5000	/	IS	09:56:07	35767	10:05:48	36348	581.256	
A090104_07	HAMO5000	/	IS	10:05:56	36356	10:05:59	36359	3.119	
A090104_10	LAMA2500	25	IS	11:15:13	40513	11:41:39	42099	1586.296	
A090104_11	LAMA2500	35	IS	11:42:31	42151	11:44:36	42276	125.984	
A090104_12	LAMA2500	40	IS, SH, IE, SI, OW	11:45:59	42359	12:01:12	43272	913.984	
A090104_13	HAMO5000	/	OW	12:09:11	43751	12:17:48	44268	517.037	

2.2.5. Auxiliary data

During the survey flights operator logs were recorded. These logs have been stored as separate files together with the data files and can be found in the Appendix A.

A downward looking SONY-video camera was installed and operated during the flights. The video mpeg-decoded files were recorded on hard disk during flight. After each flight the data was copied to magnetic tape and hard disk. The video files include GPS-PPS based time information.

In addition to the laser scanner a single beam laser altimeter (LD90), operating at 4 Hz, was mounted and run during the survey flights. The data was stored on the Medusa_P data base and a backup was carried out after flight. Table 2.8 lists the preliminary processed geo-located LD90 files.

Table 2.8.: Preliminary processed LD90 files in ESA binary format.

Date	Filename	Start time (SOD)	Stop time (SOD)	Filesize (Mb)
2008-12-21	LD90_L1B_20081221T184641_210918	67601	76158	0.9
2008-12-22	LD90_L1B_20081222T202526_243044	73526	88244	1.7
2008-12-25	LD90_L1B_20081225T154129_211911	56489	76751	2.3
2008-12-27	LD90_L1B_20081227T112045_173808	40845	63488	2.6
2009-01-04	LD90_L1B_20090104T090125_122001	32485	44401	0.4

2.2.6. Total amount of recorded and processed data

The whole data set of the CryoVEx08/09-Antarctica campaign and its pre-campaign has been stored and secured at the AWI data storage system. An overview of the total amount of the raw and processed data are given in the Tables 2.9.

Table 2.9.: Summary of collected data for the CryoVEx08/09-Antarctica campaign.

Data type	Data amount
GPS - processed	9.4 MB
INS - processed	825 MB
LD90 - processed	7.8 MB
ALS - processed	29.1 GB
ASIRAS - processed	1.1 GB
ASIRAS - raw	416 GB

2.3. Data analysis

2.3.1. Corner reflector analysis

Two corner reflectors were set up in the blue ice region, each on a cross point of two tracks. Preliminary processed GPS positions of the corner reflector locations where used during flight operation (see Table 2.10). As it is shown in Table 2.11 only one of the two corner reflectors was hit. The data quality over the corner reflectors has been checked after the survey flight with the 'ASIRASviewer3.5' software from RST. One example from the viewer is shown in Figure 2.2. Here the corner reflector shows up as a parabola of strong amplitude. By analyzing the corner responses the coherence of the ASIRAS system can be shown as well as the solved time shift problem. An example of the comparison between a theoretical modelled and measured corner response highlights this progress (Figures 2.3 and 2.4).

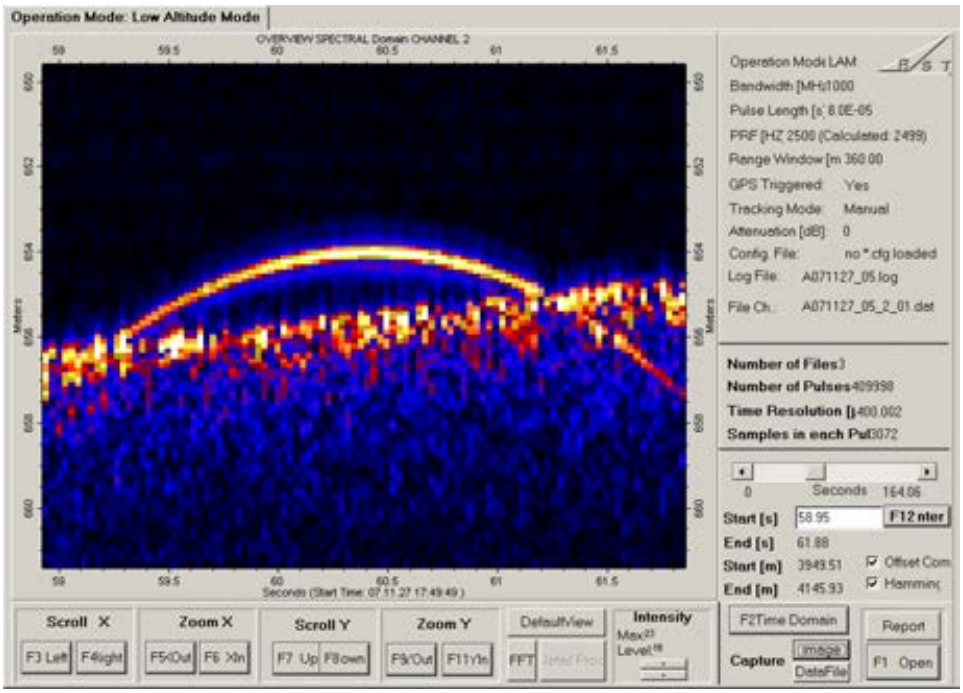


Figure 2.2.: Example of a corner reflector response displayed by the RST-'ASIRASviewer'.

Table 2.10.: Corner reflector positions.

Corner Reflector	Latitude	Longitude	Altitude	Height above ground [m]
08CY4U8	-70.972745441	13.391808705	681.50	1.79
08CY3E2	-70.95875954	13.655695571	706.10	1.65

Table 2.11.: Corner reflector analysis.

CR	Profile	Offset-track distance [m]	DGPS Time UTC and Sec. of day	ASIRAS Hit
08CY4U8	A081225_07	1.4	16:39:12.81 59952.81	/ Yes
08CY3E2	A081225_14	20.3	18:52:42.00 67962.00	/ No

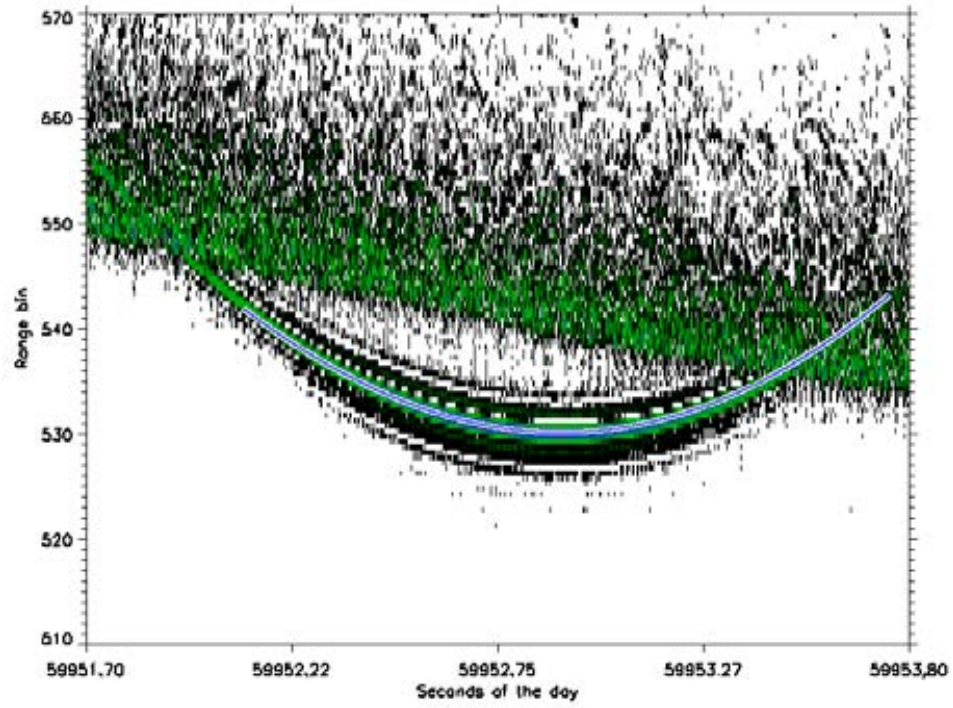
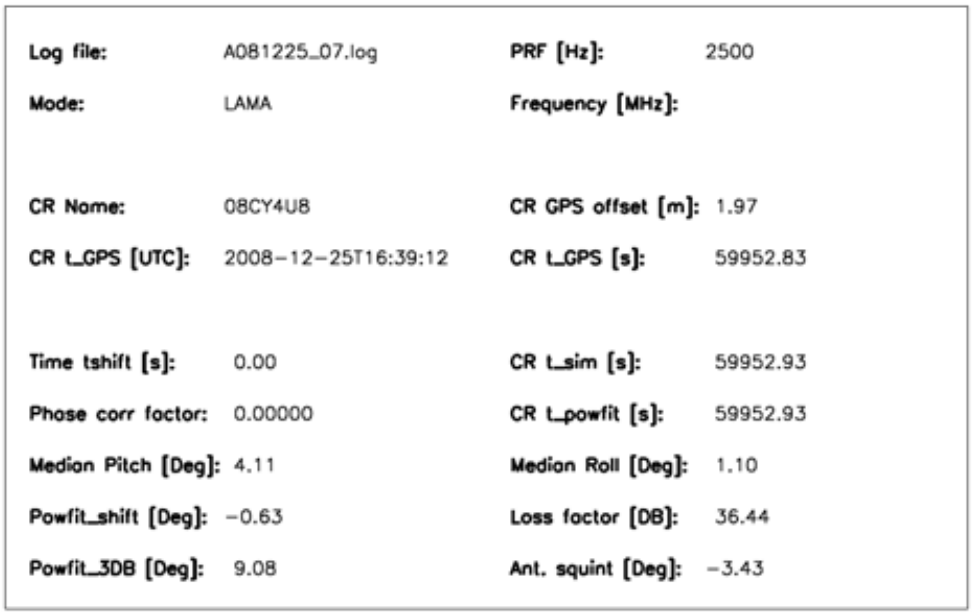
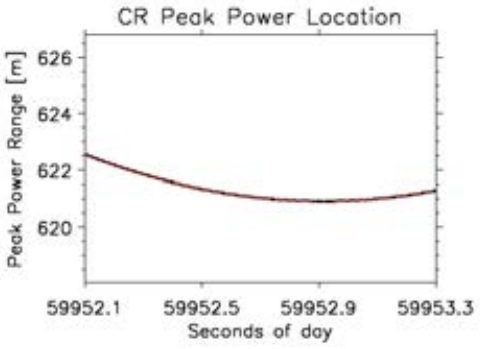


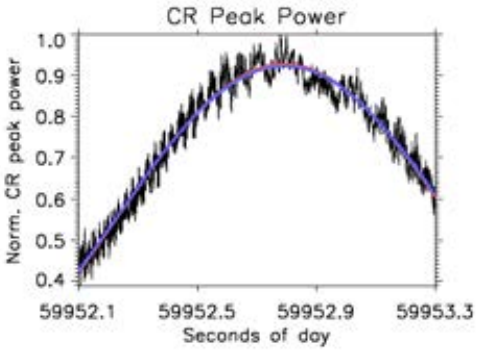
Figure 2.3.: Comparison of real data and simulated corner reflector response (blue line) of the CR CY4U8 measured on 25th December 2008.



(a) Analysis



(b) Range



(c) Power

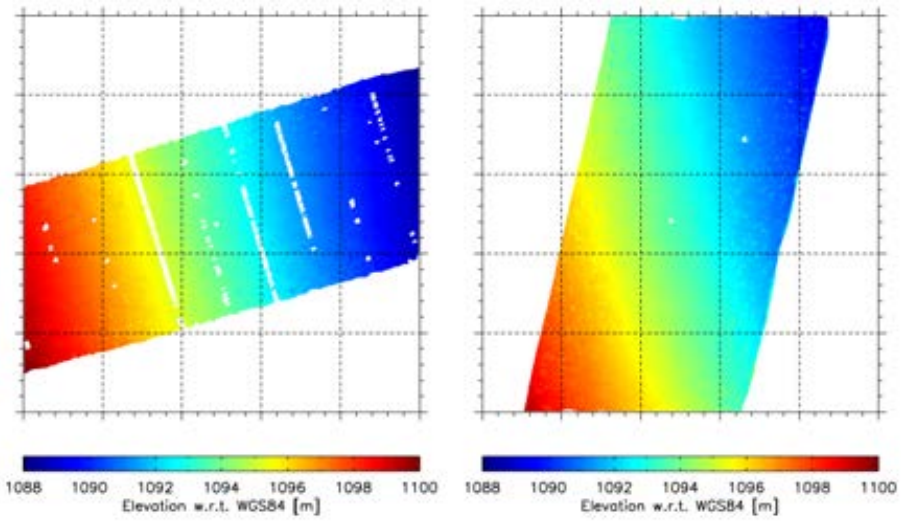
Figure 2.4.: Example of the corner reflector analysis from CR CY4U8 measured on 25th December 2008. a) the GPS offset and t_GPS gives the distance and timing of the closest approach of the GPS ground track to the CR position. The phase correction factor and time shift values (both 0.0) show that no phase correction or time shift has to be applied to the data. Respectively, b) and c) show the range history and power response of the real data (black line), fitted data (orange line) and the simulated result (blue line).

2.3.2. Laser scanner analysis

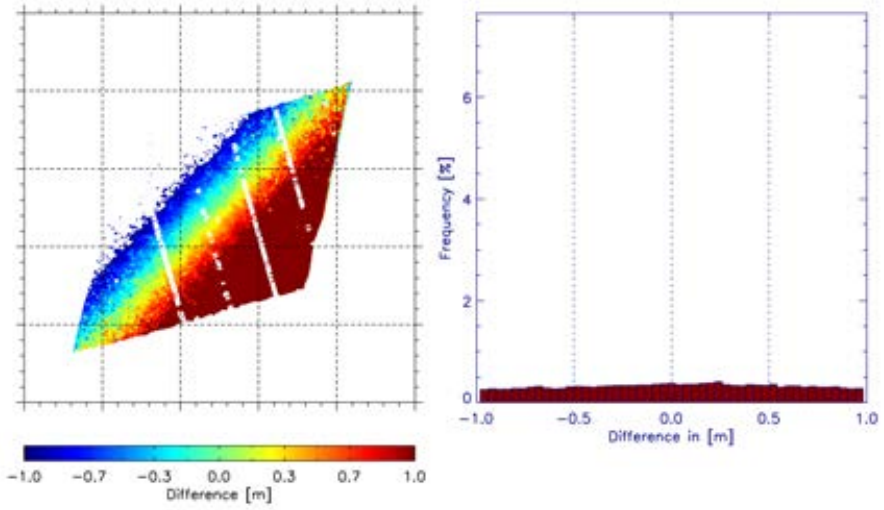
A couple of cross calibration overflights in different altitudes have been applied during the campaign. These cross calibration flights were used to determine the laser scanner squinting angles. We applied the same procedure as described in *Helm et al.* (2006). Table 2.12 lists the results of the cross calibration analysis. Figure 2.5 shows an example of the analysis with (a) and without (b) applied squint angle correction.

Table 2.12.: Laser scanner squint angle analysis

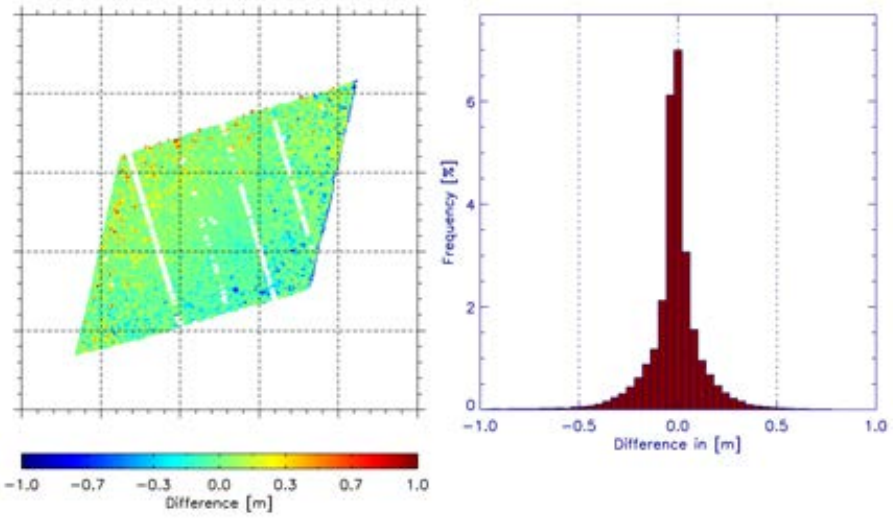
Day	Number of cross calibrations	ϑ [°]	ς [°]	ξ [°]
081225	12	-0.65	0.75	-1.0
081227	28	-0.65	0.75	-1.0



(a) DEMs of a 500 m X 500 m wide region



(b) Difference of uncorrected DEMs



(c) Difference of corrected DEMs

Figure 2.5.: Example of the laser scanner cross calibration squint angle analysis. a) Elevation models (DEM) of cross flight in the same region (500 m X 500m). Respectively, b) and c) show the difference of both DEMs with and without applied squint angle correction.

2.3.3. Runway passes

Laser scanner runway overflights are used in comparison with simultaneously acquired ASIRAS data to determine the static offset (cable length, etc.) of the ASIRAS system. This offset was not considered in the final ASIRAS level_1b processing, because of it's retracker dependency . Table 2.13 lists all runway overflights and the analysis results. In the analysis ASIRAS elevations retracked with the implemented OCOG retracker were used.

Table 2.13.: Analysis of ASIRAS and ALS data simultaneously acquired over the runway.

ASIRAS file	Start time	Stop time	Time shift [s]	Offset [m]	Stddev [m]	ALS quality	ASIRAS quality
A081225_00	15:41:12 56472	15:41:14 56474	/	/	/	no data	/
A081225_01	15:54:47 57287	15:56:00 57360	0.0	5.36	0.10	22%	roll, off-track
A081225_02	16:00:24 57624	16:01:46 57706	0.0	5.35	0.05	40%	ok, off-track
A081225_03	16:04:32 57872	16:06:01 57961	0.0	5.29	0.10	10%	roll
A081225_04	16:10:13 58213	16:15:57 58557	/	/	/	no data	/
A081225_21	21:08:53 76133	21:13:51 76431	0.0	5.34	0.04	100%	good
A081225_22	21:16:30 76590	21:18:36 76716	0.0	5.34	0.03	100%	good
A081227_00	11:29:40 41380	11:31:56 41516	/	/	/	no data	/
Mean				**5.34**			

3. Field party operations

3.1. Overview

The two geodesists forming the TU Dresden group flew onboard a IL76TD aircraft from Cape Town to Antarctica on November 11 2008. The Novolazarevskaya airfield is located south of the Schirmacher Oasis on an altitude of about 500 m. The group used the airfield camp about 12 km from the Russian Novolazarevskaya base as the logistical base for the entire field campaign. From November 18 to December 20 a field camp close to the traverse waypoint U09 in the blue ice area about 85 km east of the Schirmacher Oasis was established. A second field camp close to the traverse waypoint S10 in the accumulation area about 40 km south of the Oasis was set up from January 3rd to January 23rd. On February 11 the group returned to Cape Town onboard a IL76TD aircraft.

3.2. GPS reference stations

In oder to reduce systematic effects the kinematic GPS data need to be analyzed with respect to stable reference stations. Tables 3.1 and 3.2 summarize the reference stations. During CryoVEx08/09 three reference stations on bedrock were installed in the vicinity of Schirmacher Oasis: The stations FOR1 and FOR2 are located in the oasis itself, the station AERO is located on a nunatak in a distance of about 3 km from the Airbase Camp. All receivers run without data loss over the entire observation time period. While the receivers at FOR1 and FOR2 tracked GPS satellite signals only, the TRIMBLE R7 receiver and the geodetic TRM57971.00 antenna at AERO also provides observations of the Russian GLONASS system (Figure 3.1).
In order to reduce the baseline lengths between the kinematic receivers and the reference stations, additional static GNSS (GPS and GLONASS) observations were carried out in the field camps U09 and S10. Here, the GNSS antenna was mounted on a tripod in the snow. The position change rates of these stations are dominated by the ice movements. In the analysis the station movement of CU09 was estimated to be (North-, East-, Up-Component) $v_N = 12.862\ m/yr$, $v_E = -10.354\ m/yr$, $v_U = 0.057\ m/yr$. The station movement of CS10 was estimated to be $v_N = 46.872\ m/yr$, $v_E = 48.464\ m/yr$, $v_U = -4.101\ m/yr$. This corresponds to an ice movement of 4.5 cm/day for CU09 and of 18.5 cm/day for CS10. It has to be stated that due to possible subsidence effects of the tripods, the vertical velocity components can not be interpreted glaciologically.

Table 3.1.: GPS reference stations during CryoVEx08/09

Marker	Name	Latitude [deg min sec]	Longitude [deg min sec]	Height [m]
Forster 1	FOR1 66023M001	-70 46 40.58	11 49 30.23	152.9
Forster 2	FOR2 66023M002	-70 46 27.21	11 50 12.43	128.8
Aerodromnaya	AERO	-70 47 39.71	11 37 13.68	514.9
Camp U9 temporary	CU09	-70 58 57.85	13 25 53.72	696.9
Camp S10 temporary	CS10	-71 07 08.13	11 38 56.40	1027.8

Table 3.2.: Observations at GPS reference stations

Station-ID	Receiver	Antenna	Data Sampl.	Observation-interval
Reference stations on bedrock				
FOR1	Trimble 4000SSi S/N 17687	TRM14532.00 S/N 66181	1s	Nov 14 2008 - Feb 03 2009 08:319 - 09:034
FOR2	Trimble 4000SSi CORS S/N 18000	TRM14532.00 S/N 66167	5s	Nov 14 08 - Feb 03 2009 08:319 - 09:034
AERO	Trimble R7 S/N 30139	TRM57971.00 S/N 30403865	1s	Nov 16 2008 - Jan 31 2009 08:321 - 09:031
Reference stations on ice				
CU09	Trimble R7 S/N 30135	TRM57971.00 S/N 30403822	1s	Nov 25 2008 - Dec 19 2008 08:330 - 08:354
CS10	Trimble R7 S/N 30135	TRM57971.00 S/N 30403683	1s	Jan 06 2009 - Jan 09 2009 09:006 - 09:009 Jan 18 2009 - Jan 23 2009 09:018 - 09:023

3.3. Kinematic GPS measurements

For the kinematic GPS measurements a geodetic GNSS antenna TRM57971.00 was mounted on a tripod on a Nansen sledge (rover). A Trimble R7 geodetic receiver and a battery were stored in a aluminium box next to the tripod (Figure 3.3). Besides GPS this receiver also stored GLONASS observations. The sledge was pulled by a two-stroke Lynx Yeti 550 snow mobile. The velocity was limited to about 10 km per hour on blue ice and about 15 to 20 km per hour on snow. All kinematic tracks were observed with a data sampling of 1 Hz. This yields to a long track resolution of about 3 m on blue ice and 4 to 6 m on snow. In order to assess the measurement accuracy cross over points were observed. In total more than 1800 km kinematic profiles were observed in the work area. Figure 3.4 gives an overview of all kinematic GPS profiles. A more detailed view of the blue ice region is shown in Figure 3.5. A summary of all profiles is given in Table 3.3

3.3.1. Kinematic GPS measurements at traverses

Kinematic GPS measurements were carried out along two glaciological traverses:
The Untersee traverse covers a total length of about 120 km and goes from the Schirmacher Oasis in south eastern direction to the Gruber mountains and lake Untersee. The traverse is crossing an ablation area and is characterized by blue ice. Partly, the blue ice is covered by thin layers of snow up to a thickness of few decimeter. The complete traverse was observed 4 times. Single tracks were observed by two independed rovers, which allows a direct comparison of the determined ice surface heights. A summary of the profiles on Untersee traverse is given in Table 3.3.
The Southern traverse goes from the Schirmacher Oasis south to the Humboldt mountains. The total length is about 100 km. The traverse is characterized by a transition zone between ablation and accumulation area and accumulation area. Table 3.4 summarizes the GPS profiles at the Southern Traverse.

3.3.2. Kinematic GPS test grids

On selected locations dense grid profiles were surveyed. The surveyed area is about 1 km^2. The mesh size is 50 m. For an inner square of 200 m by 200 m the mesh size was reduced to be 10 m. The total profile length of a single test grid is more than 50 km.

Table 3.3.: Summary of all kinematic GPS profiles in the blue ice area of Untersee traverse.

Profile	Date	Waypoints	Approx. Length
A001	16.11.08	Airbase – AERO – Airbase	10 km
A002	18.11.08	Airbase – Camp U9	75 km
A003	20.11.08	Camp U9 – Airbase	95 km
A004	22.11.08	Airbase – Novolazarevskaya	12 km
A005	23.11.08	Novolazarevskaya – Airbase	12 km
A006	24.11.08	Airbase – Camp U9	75 km
B006	24.11.08	Airbase – Camp U9	75 km
A007	28.11.08	Camp U9 – U9 – CY4E1 – Grid 4 – CY2U14U08 – CY4U14U08 – U9 – Camp U9	80 km
A008	30.11.08	Camp U9 – CY1U14U08 – Untersee	51 km
A009	01.12.08	Untersee – OTR1 – Camp U9	50 km
A010	03.12.08	Camp U9 – U9 – CY4U14U08 – CY4WP1WP2 – WP1WP2E2 – CY1CY3 – CY3E2 – E1E2 – U14U08E1 – CY1U14U08 – U09 – Camp U9	50 km
A011	04.12.08	Camp U9 – CY4U14U08 – Camp U9	5 km
A012	05.12.08	Camp U9 – CY4U14U08 – Grid 7 - Camp U9 (aborted due to power failure)	60 km
A013	06.12.08	Camp U9 – CY4U14U08 – Grid 7 - Camp U9	60 km
A014	07.12.08	Camp U9 – CY3E2 – Grid 8 - Camp U9	68 km
A015	12.12.08	Camp U9 – OTR1 – Untersee	55 km
A016	13.12.08	Untersee – Camp U9	50 km
A017	17.12.08	Camp U9 – CY4U14U08 – Camp U9 – CY3E2 – Camp U9	21 km
A018	18.12.08	Camp U9 – U14U08E1 – Grid 9 – Camp U9	88 km
A019	20.12.08	Camp U9 – Airbase	78 km
B019	20.12.08	Camp U9 – Airbase (aborted due to power failure)	78 km

Five test grids were observed in the work area (Figures 3.6, 3.7, 3.8, 3.9, 3.10). The test grids are located at cross over points of subsatellite tracks or tracks of the airborne surveys. The actual dimensions of each test grid were defined depending on the pre-planned airborne survey tracks. Four test grids were surveyed in the blue ice area (Grid No. 4, 7, 8 and 9) and one additional test grid was observed in the accumulation area (Grid No. 6). Parts of the test grids in the blue ice area are covered with a thin layer of snow. The locations of the transition between the pure blue ice and the areas with partly snow coverage were surveyed and are marked in Figure 3.7 and 3.9). The test grid 4 featured snow coverage over large parts of the grid. The depth of the snow layer was measured at 45 locations and a surface model was interpolated (Figure 3.6).

3.3.3. Data analysis

In order to get a assessment of the accuracy of the kinematic GPS profiles, the profile a013 was analyzed. The analysis was performed using the Bernese GPS Software in its latest version 5.0. First, the reference stations on bedrock as well as the reference station CU09 were determined in a global reference frame. Later, the kinematic GPS profile was estimated with respect to these reference stations. Then, the accuracy of the determined coordinate trajectories were evaluated using a crossover analysis (Figure 3.11). The results show the potential of kinematic GPS observations on blue ice. The RMS of the more than 1300 crossover height differences was estimated to be 2.3 cm. The histogram clearly shows, that most of the height differences are smaller than 5 cm.

Table 3.4.: Summary of all kinematic profiles on Southern Traverse.

Profile	Date	Waypoints	Approx. Length
A020	03.01.09	Airbase – Camp S10	50 km
A021	06.01.09	Camp S10 – Airbase	50 km
A022	07.01.09	Airbase – Camp S10	50 km
A023	09.01.09	Camp S10 – Insel	48 km
A024	10.01.09	Insel – Humboldt – Insel	45 km
A025	11.01.09	Insel – SKA1 – Camp S10	42 km
A026	12.01.09	Camp S10 – S09 – F331 – S09 – Airbase	48 km
A027	16.01.09	Airbase – Camp S10 – Insel	85 km
A028	17.01.09	Insel – Humboldt – Insel	45 km
A029	18.01.09	Insel – SKA1 – Camp S10	42 km
A030	20.01.09	Camp S10 – F33 – F27 – F33 – Camp S10	100 km
A031	21.01.09	Camp S10 – F33 – F39 – F33 – Camp S10	80 km
A032	22.01.09	Camp S10 – Grid 6 – F331 – Camp S10	72 km
A033	23.01.09	Camp S10 – Airbase	45 km

Table 3.5.: Summary of densified grids.

Grid Number	GPS profile	Crossover Point	Date	Profile length
4	A007	CryoSat-CY2/CryoSat-CY4	28.11.2008	56 km
7	A012, A013	CryoSat-CY4/Flight-U14U08	06.12.2008	56 km
8	A014	CryoSat-CY3/ENVISat-E2	07.12.2008	48 km
9	A016	ENVISat-E1/Flight-U14U08	13.12.2008	54 km
6	A032	true flight tracks CY7/U14U08	22.01.2009	53 km

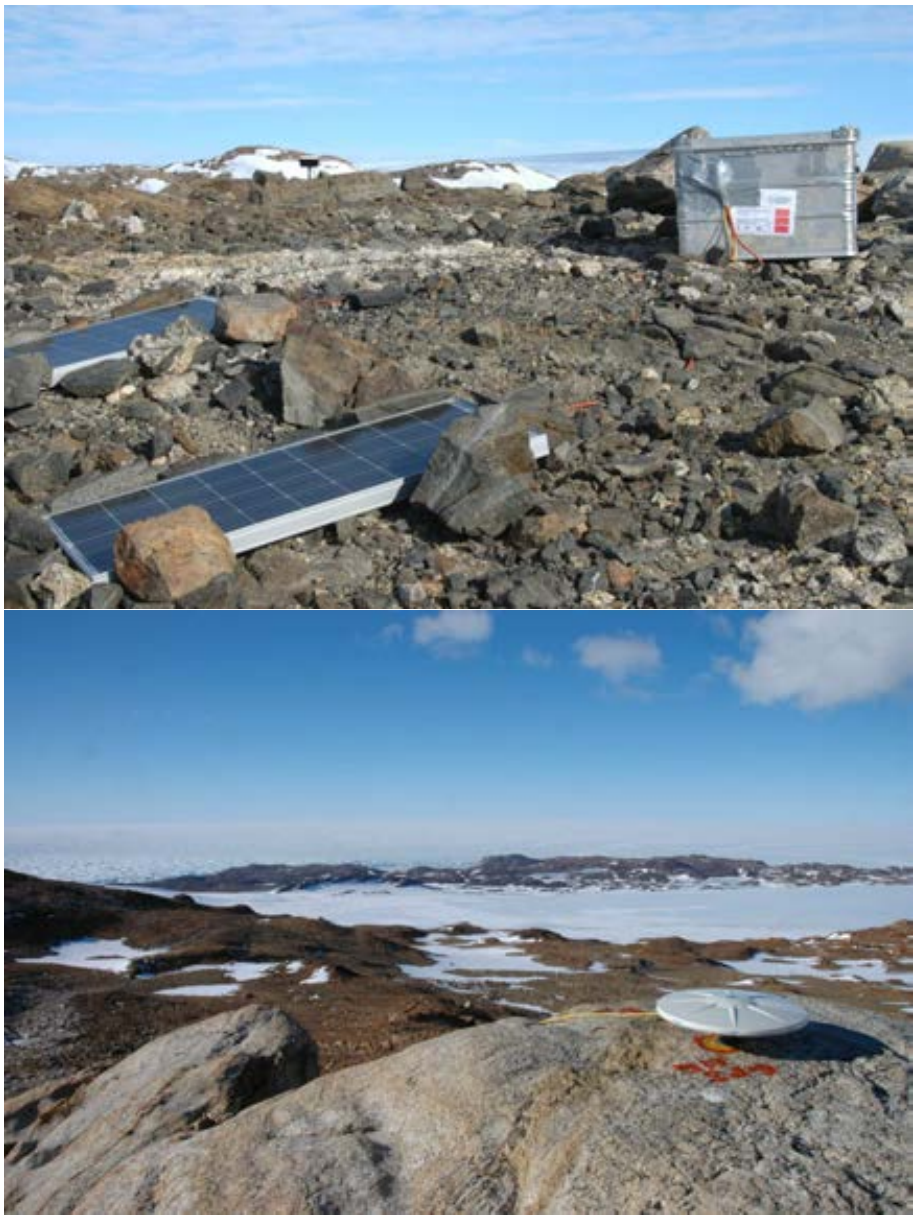


Figure 3.1.: Setup of GPS reference station on bedrock. Top: GPS station FOR2. The GPS antenna (Trimble TRM14532.00) is located in the left center of the picture. The receiver and the data logging unit is stored in the aluminium box. The solar panels provide the power. Bottom: GPS reference station AERO. The picture shows the Trimble TRM57971.00 GNSS antenna which receives observations of the GLONASS system in addition to GPS data.

Figure 3.2.: Setup of GPS reference station on ice (field camp U9).

Figure 3.3.: Setup of kinematic GPS observations. A GNSS antenna (TRM57971.00) is mounted on a tripod on a Nansen sledge. The aluminium box on the sledge houses the TRIMBLE R7 GNSS receiver and the battery. The sledge is pulled by a two-stroke Lynx Yeti 550 snow mobile.

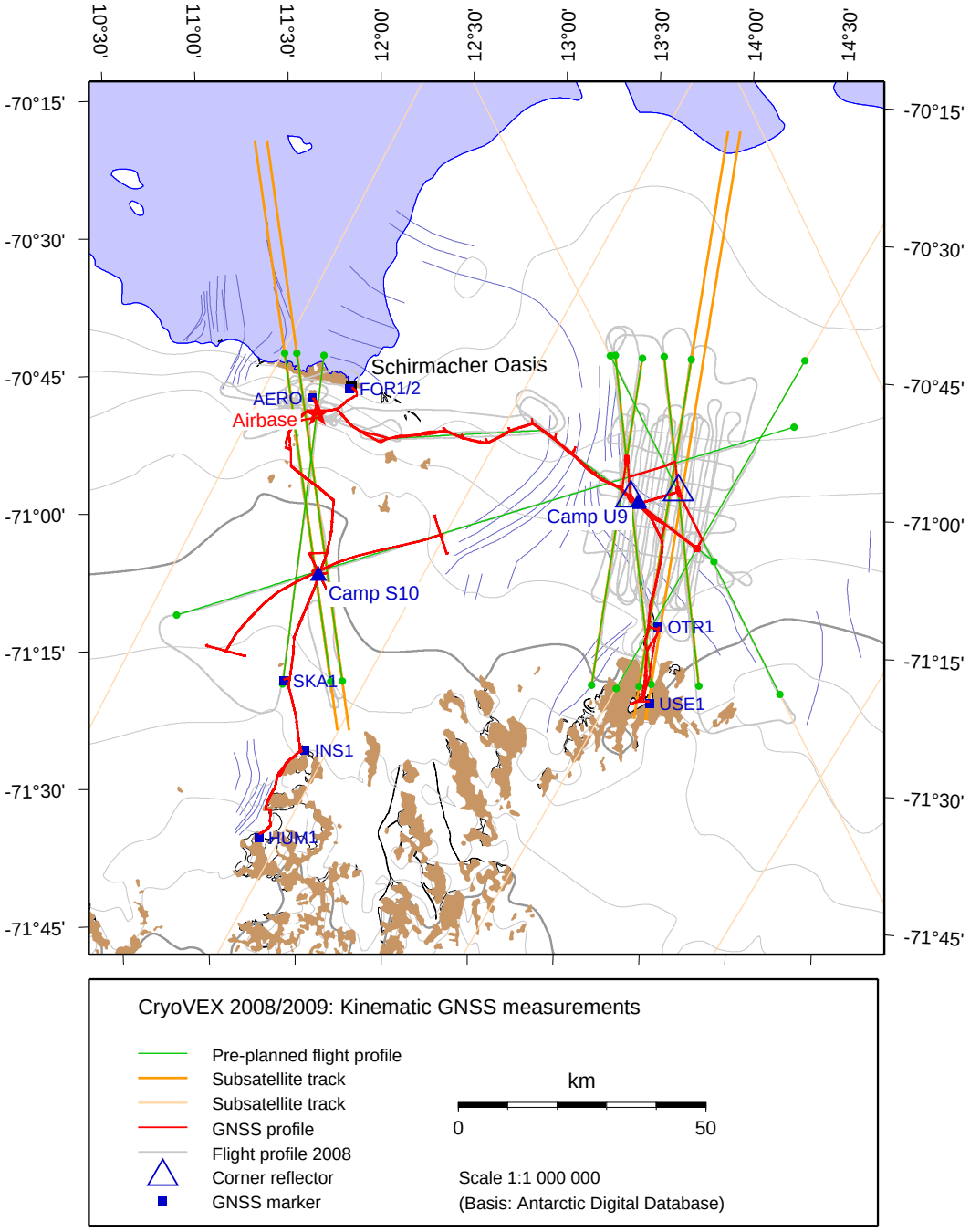


Figure 3.4.: Overview of GPS profiles in the work area.

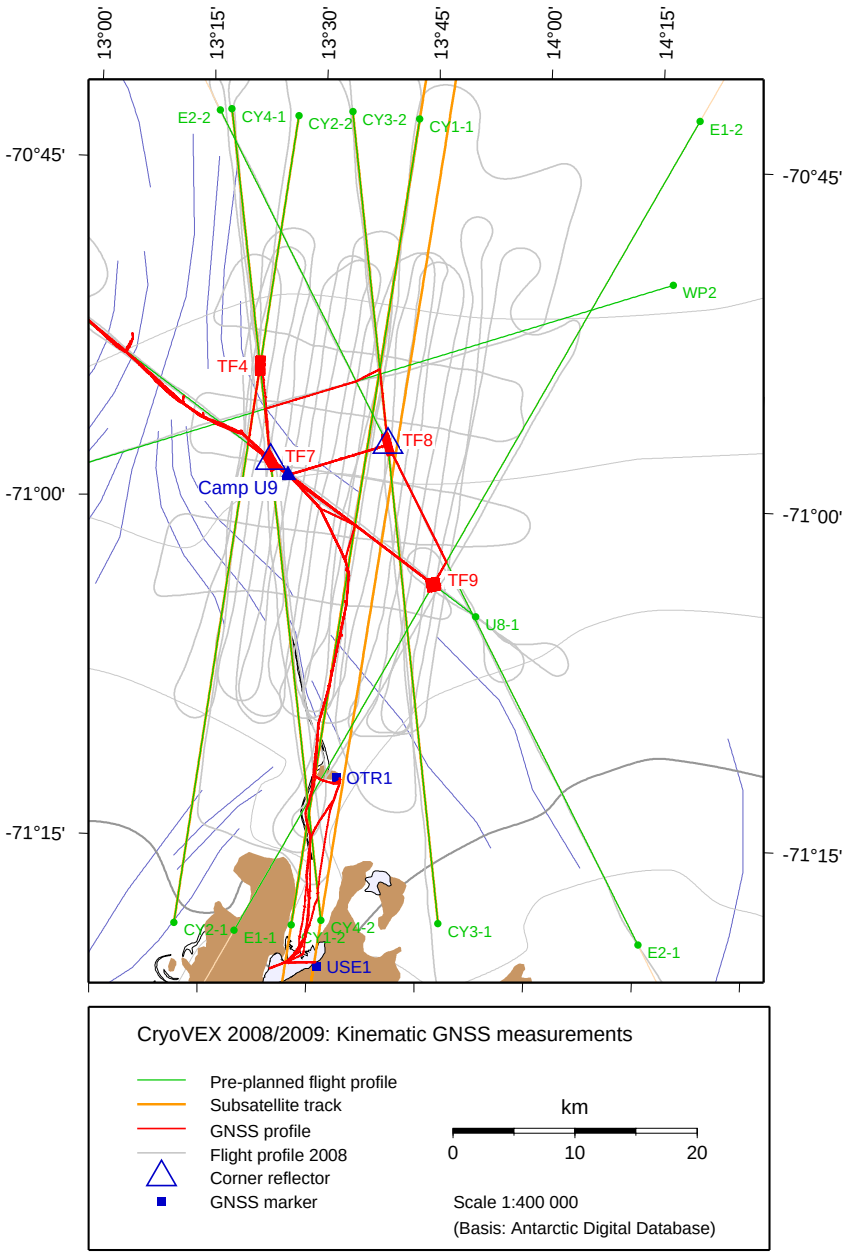


Figure 3.5.: CryoVEx 08/09 GPS profiles: Detail Untersee traverse around Camp U9. The locations of the dense test grids are marked with TF (cf. Section 3.3.2).

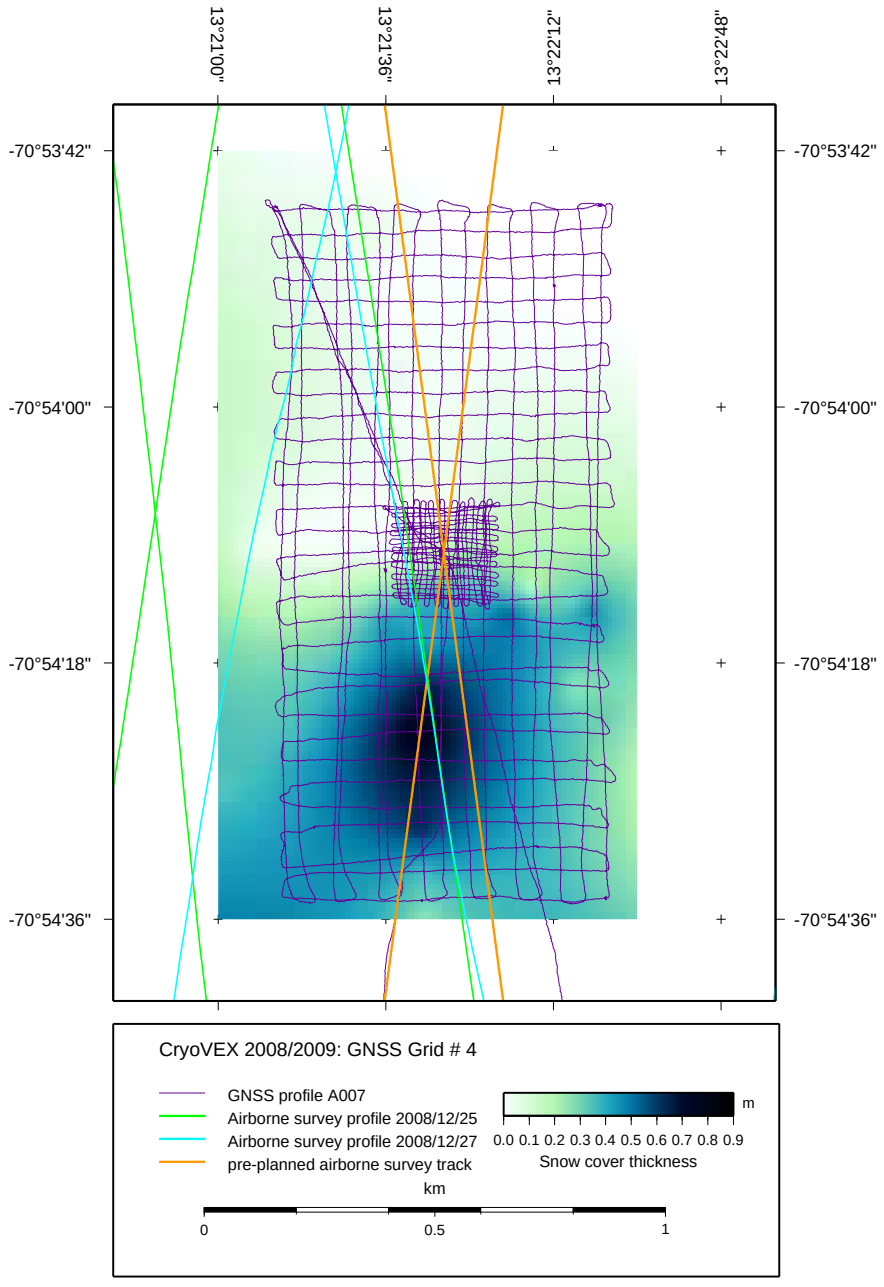


Figure 3.6.: Kinematic GPS tracks at Grid 4. The southern part of the area is partly covered by a thin layer of snow. The depth of the snow layer was measured and a correction surface was modeled.

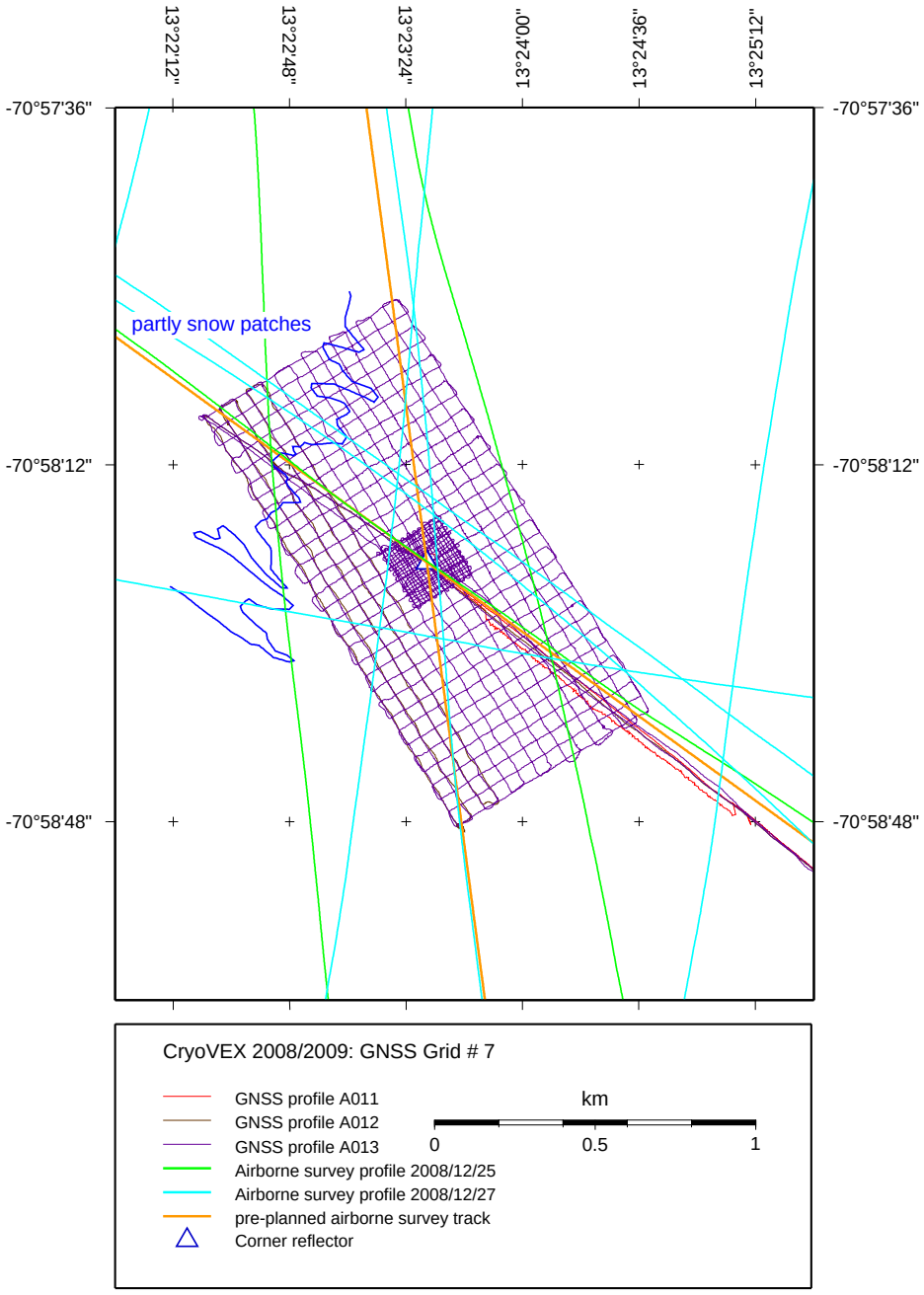


Figure 3.7.: Kinematic GPS Grid No. 7.

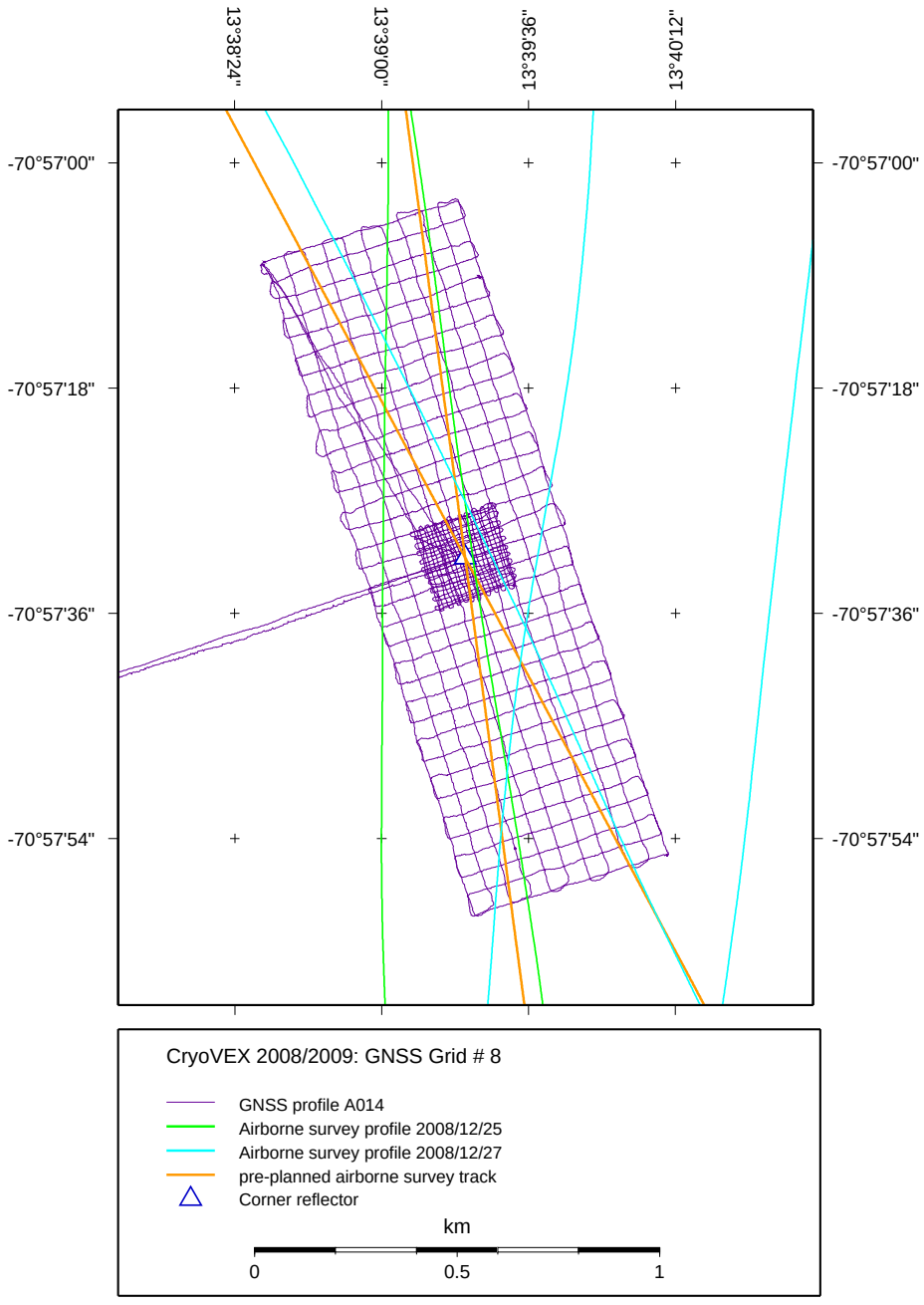


Figure 3.8.: Kinematic GPS Grid No. 8.

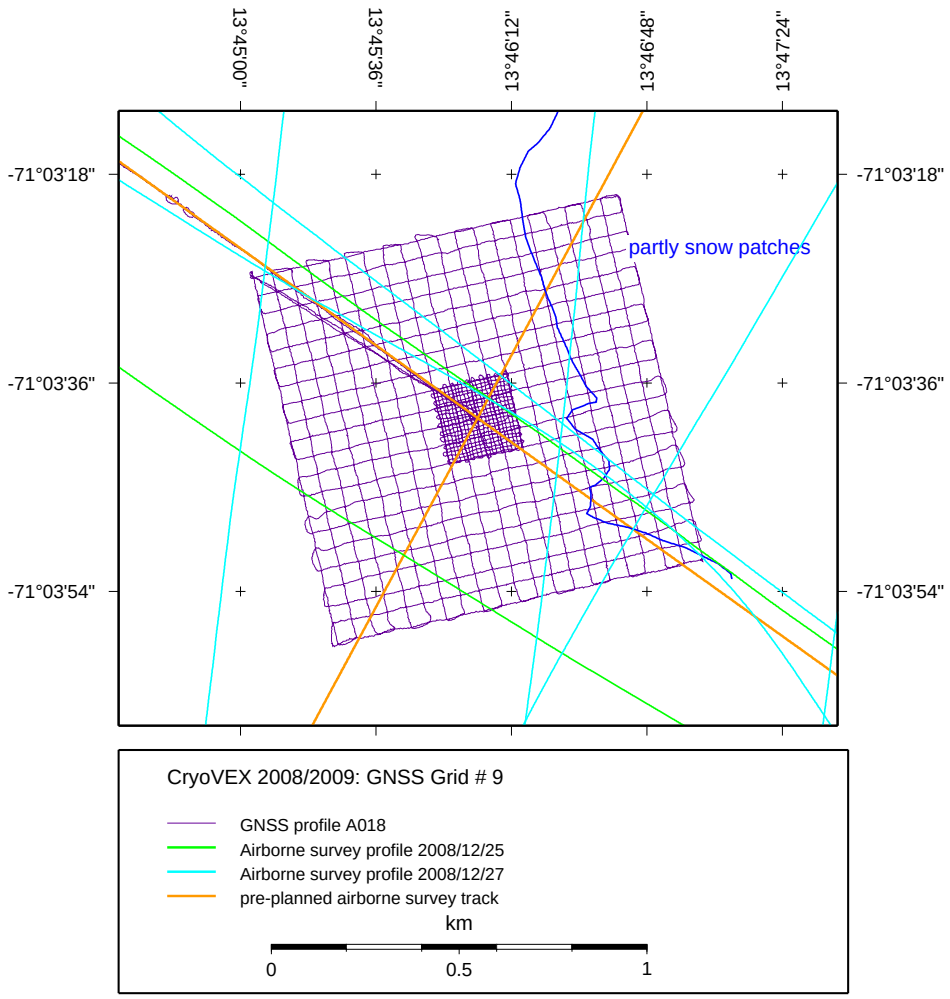


Figure 3.9.: Kinematic GPS Grid No. 9.

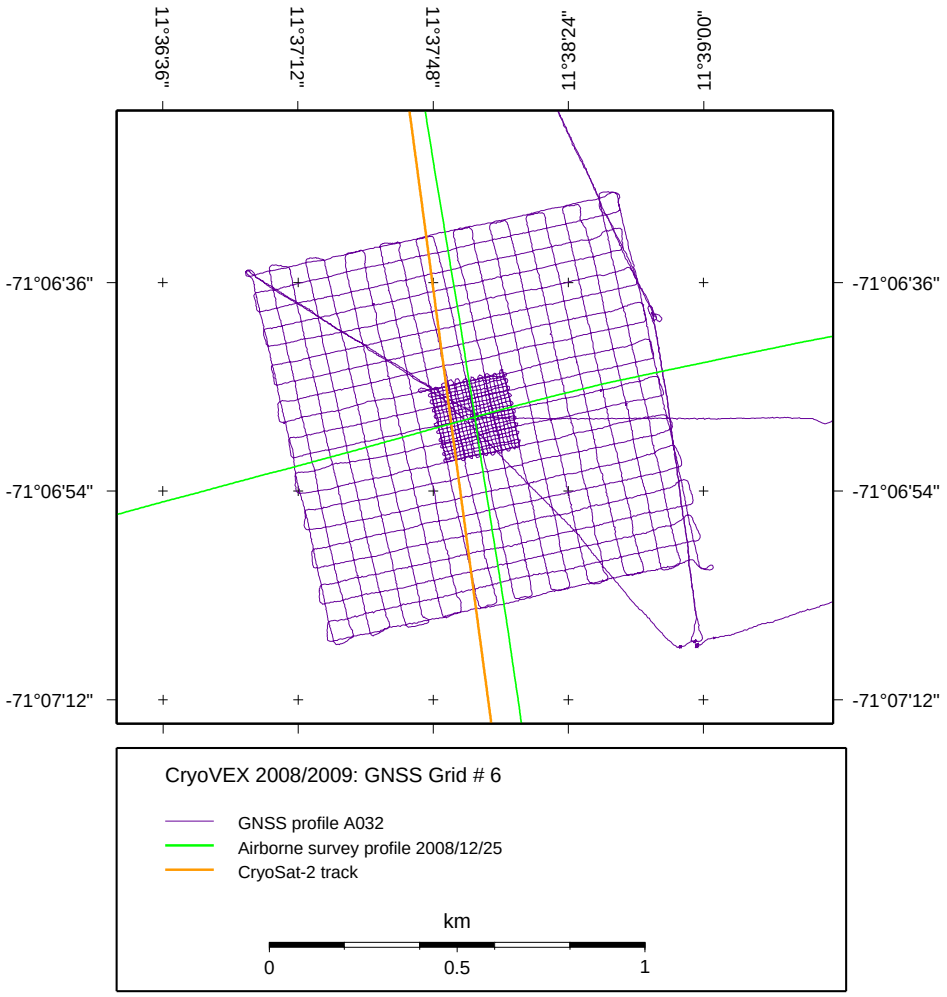


Figure 3.10.: Kinematic GPS Grid No. 6 in the accumulation area close to Camp S10.

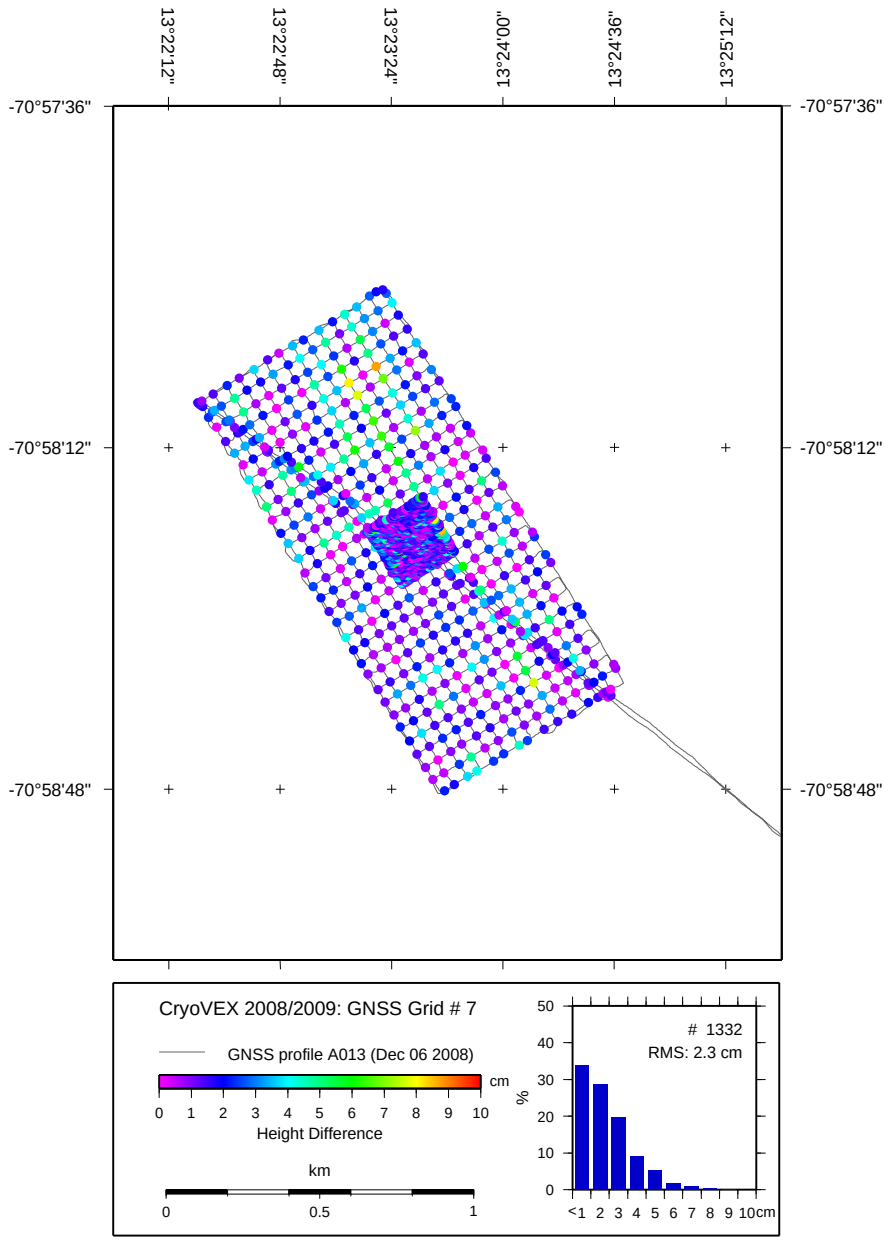


Figure 3.11.: Results of a crossover analysis for test grid no. 7 (see Figure 3.7). The observation data of the kinematic profile a013 was used for the analysis.

4. Preliminary comparison of surface elevations of GPS grid 7 determined with GPS, ALS and ASIRAS

Here, some preliminary results of the comparisons between the ground based GPS measurements and the airborne laser scanner (ALS) and radar altimeter measurements of GPS grid 7 are shown. Figure 4.1 displays the GPS DEM of grid 7 overlaid by the ALS DEM. Surface elevations are increasing by roughly 3° from north to south from approximately 660 m to 700 m.

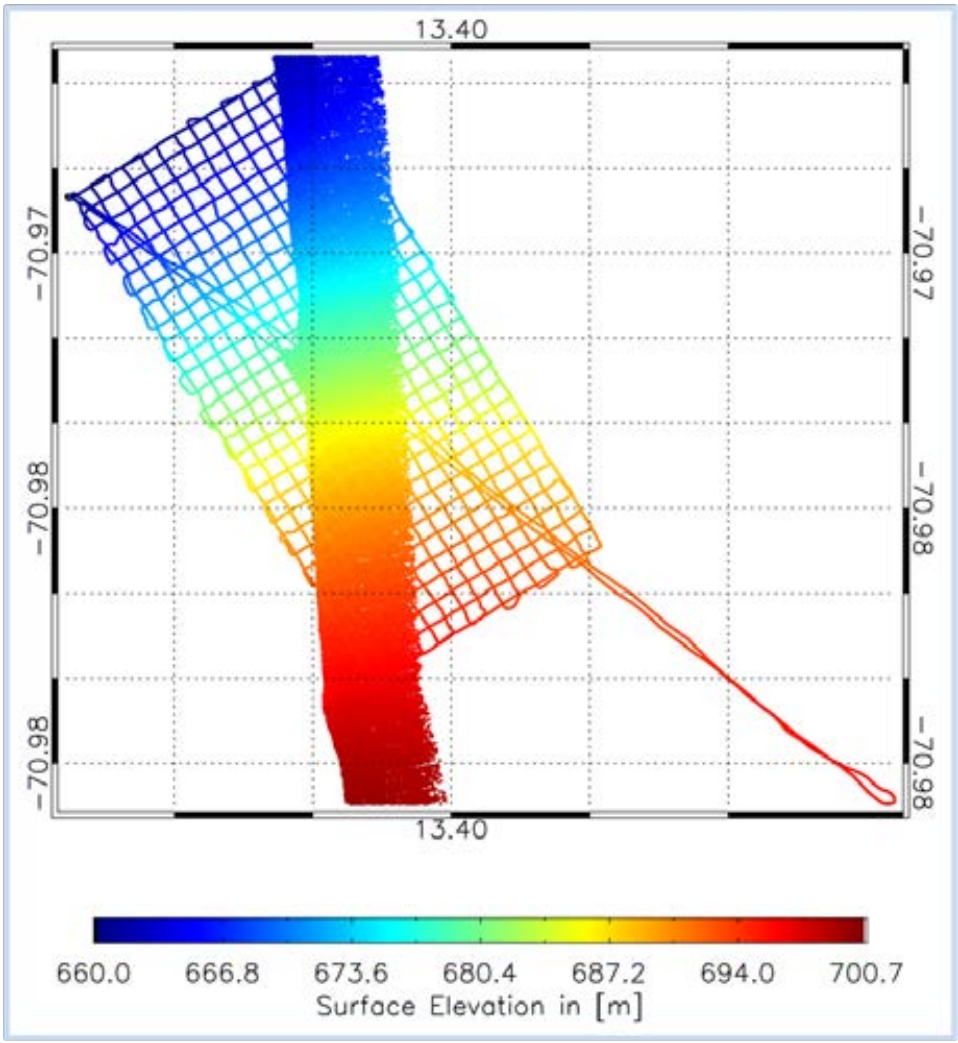


Figure 4.1.: Surface elevations of GPS grid 7 and laser scanner DEM of the same region.

The results of the comparison between the GPS surface elevations and two independent ALS DEMs are shown in Table 4.1 and Figures 4.2 a) and b). The Median Difference between GPS and ALS of the two crossings is -0.06 m and -0.20 m, respectively. The standard deviation is 0.09 m in both cases. The low standard deviation show that the relative accuracy of the ALS measurements are good, however an offset of roughly 0.14 m between both crossings exists. This offset might be caused by cycle slips in the GPS post processing and/or bad quality of the airborne GPS data.

Table 4.1.: Comparison of GPS surface elevation and ALS DEMs

	Crossing 1	Crossing 2
Median of Difference between ALS DEM and GPS [m]	-0.06	-0.20
Stddev of Difference between ALS DEM and GPS [m]	0.09	-0.09

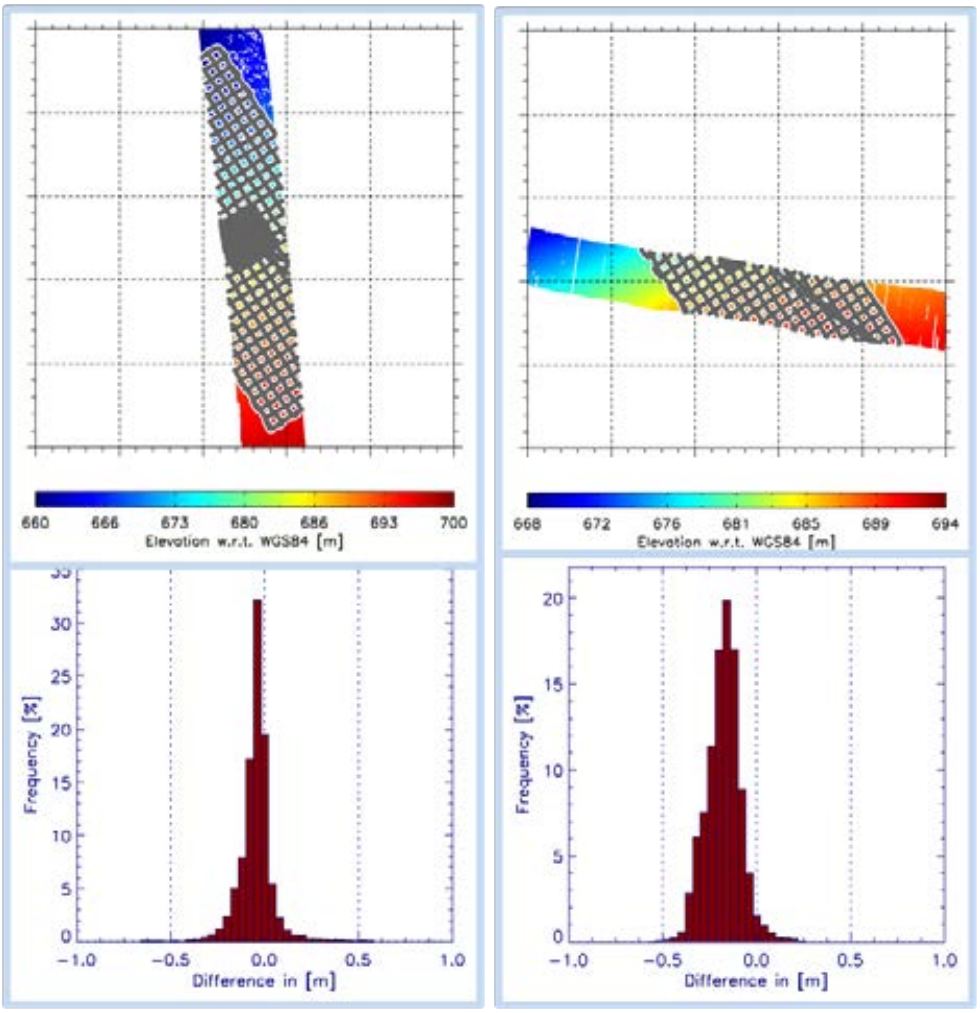


Figure 4.2.: Comparison of surface elevations measured with GPS and two independent ALS crossing.

The results of the comparison between ALS and ASIRAS in the GPS grid 7 region are presented in Figure 4.3 b). Figure 4.3 a) shows the true color image of the laser scanner swath. Clearly visible are small snow patches (green color) on top of the the blue ice (reddish). The red line in the centre

of the swath reflects the ASIRAS L1B surface locations. Interrupted areas of this line are due to the high roll angle and are not used in the comparison with the laser scanner elevation model. The comparison shows a median difference between ASIRAS and ALS of 0.0 m with a standard deviation of 0.05 m. The results are very interesting, since one would assume a penetration of the radar into the snow and no penetration of the laser. This would cause a small elevation offset to the laser scanner data, however no difference is observed in the grid 7 region. Therefore laser and radar returns seem to be dominated by the same surface. A possible scenario could be that the received returns of both radar and laser are dominated by the small blue ice patches in between the snow patches. If this is the case then the observed offset from the ALS DEM to the GPS data in Table 4.1 is real and not caused by quality or processing issues. All results and interpretations are very preliminary, but they show valuable data sets for the validation of ASIRAS and CryoSat.

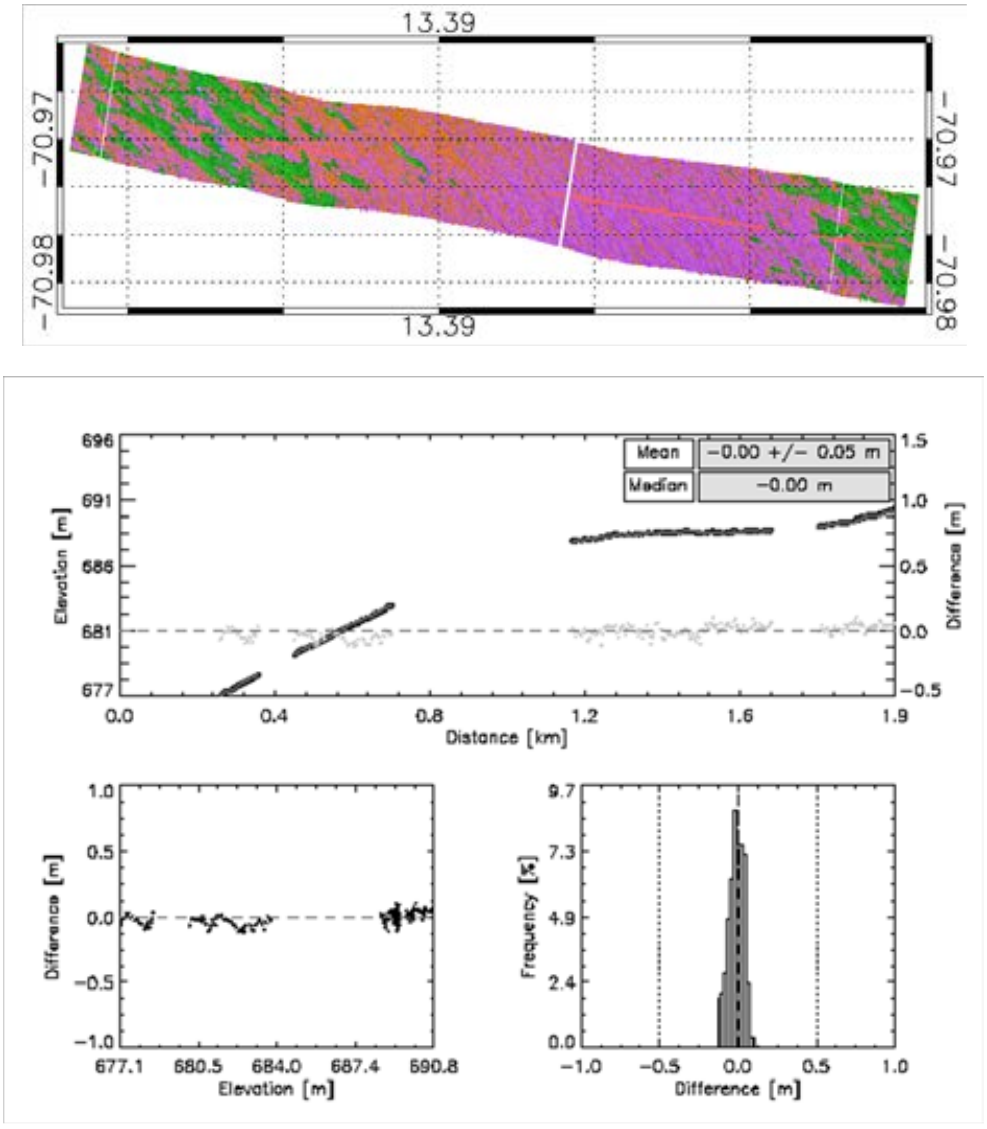


Figure 4.3.: Comparison of surface elevations measured with GPS and two independent ALS crossing.

5. Summary

The airborne part of the CryoVEx08/09-Antarctica campaign has been carried out successfully by AWI and the gathered data sets are now stored and secured at the AWI data storage system. A total of 26 hours were flown with the POLAR 5 where laser scanner data and ASIRAS radar data were gathered on a couple of preliminary CryoSat tracks, at the blue ice validation sites close to Novolazarevskaya Airbase, along lines in the accumulation area of Potsdam glacier and around Neumayer. Additional a 25x20 km large grid with a line spacing of 1x5 km over the blue ice region was surveyed. About 20 hours were spent on flights over the main validation and measurement sites, and the rest on transit flights and ground time. Preliminary analysis of the data sets show good results with some limitations in the laser scanner quality. At the writing of this report, the combined analysis of the GPS, laser scanner and ASIRAS data is in progress at TU Dresden and AWI. Some of the preliminary results are shown in chapter 4.

The ground based GPS observations carried out by TU Dresden were mainly focused on the blue ice area east of the Schirmacher Oasis. The Untersee traverse with a total length of 120 km was surveyed by four independent profiles. Additionally, four test grids were observed in the work area. The Southern traverse covers the transition zone between ablation area in the North and accumulation area in the South. The 100 km long traverse was observed independently 4 times. In the accumulation area an additional test grid was observed. Another profile follows the flow line of Potsdam glacier.

Summarized a comprehensive set of ground data could be collected during CryoVEx08/09 which covers areas with different properties concerning backscattering of remote sensing signals.

A. Airborne Log with GPS track plot

A.1. CryoVE08/09-Antarctica - December 21st

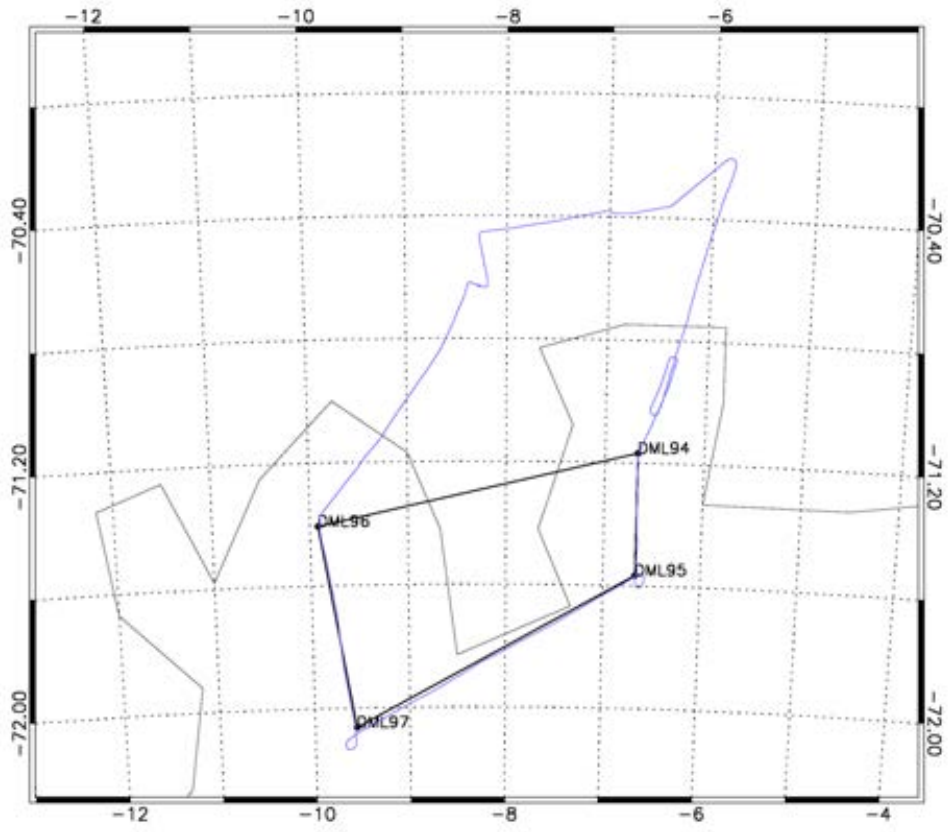


Figure A.1.: Overview of flight activity on 21st December 2008. Blue line shows GPS track, black lines are showing the planned profiles.

Table A.1.: Event log of flight at December 21st.

Event	Time (UTC)	Description
1	18:40:12	ready for takeoff (lat=70:37.9225S lon=008:16.1671W alt=+0049)
2	18:44:50	takeoff (lat=70:37.9020S lon=008:14.6876W alt=+0179)
2A	18:50:00	asiras calibration (MODE - file: LAM - 05, LAMA - 06, HAM -07)
2B	18:53:00	asiras lamo2500_00 (300 m, open ocean)
2C	18:55:00	asiras stop
2D	18:56:00	asiras lama2500_01 (300 m, open ocean)
2E	18:58:00	asiras stop
continued		

Event	Time (UTC)	Description
3	18:58:13	2000 feet (lat=70:25.0339S lon=007:31.6572W alt=+0348)
3A	19:00:00	asiras lama2500_02 (600 m, open ocean)
3B	19:02:00	asiras stop
4	19:03:27	2300 feet (lat=70:22.9758S lon=007:01.9816W alt=+0655)
4A	19:05:00	asiras lamo2500_03 (700 m, open ocean)
4B	19:07:00	asiras stop
4C	19:08:00	asiras lama2500_04 (700 m, open ocean)
4D	19:10:00	asiras stop
4E	19:11:00	asiras lama2500_05 (900 m, open ocean)
4F	19:12:00	asiras stop
4G	19:13:00	asiras lamo2500_06 (900 m, open ocean)
4H	19:15:00	asiras stop
4I	19:15:00	asiras lamo2500_07 (900 m, open ocean)
4J	19:19:00	asiras stop
4K	19:20:00	asiras lamo2500_08 (600 m, shelf ice)
4L	19:25:00	asiras stop
5 - 22	19:25-19:58	ALS testing (try to run the instrument - no success)
23	19:58:55	asiras lama2500_09 (600 m, DML94 - DML95) (lat=71:09.8858S lon=006:39.3665W alt=+1304)
24	19:59:09	dml94 (lat=71:10.4714S lon=006:40.1203W alt=+1306)
24A	20:10:00	asiras stop (recording error)
24B	20:10:00	asiras lama2500_10 (600 m)
25	20:12:53	asiras stop (lat=71:34.2364S lon=006:34.7246W alt=+1182)
26	20:13:53	asiras lama2500_11 (600 m, DML95 - DML97) (lat=71:33.7821S lon=006:38.5071W alt=+1180)
27	20:42:41	asiras stop (lat=72:06.3995S lon=009:39.6975W alt=+1325)
28	20:46:28	asiras lama2500_12 (600 m, DML97 - DML96) (lat=72:04.3359S lon=009:34.6075W alt=+1365)
29	20:46:56	DML97 (lat=72:03.2119S lon=009:34.8391W alt=+1366)
33	21:06:01	dml 96 (lat=71:29.9830S lon=009:51.1755W alt=+1267)
34	21:06:14	asiras stop (lat=71:29.9830S lon=009:51.1755W alt=+1265)
37	21:07:17	landing (lat=71:21.8728S lon=009:52.3798W alt=+1223)

A.2. CryoVE08/09-Antarctica - December 22nd

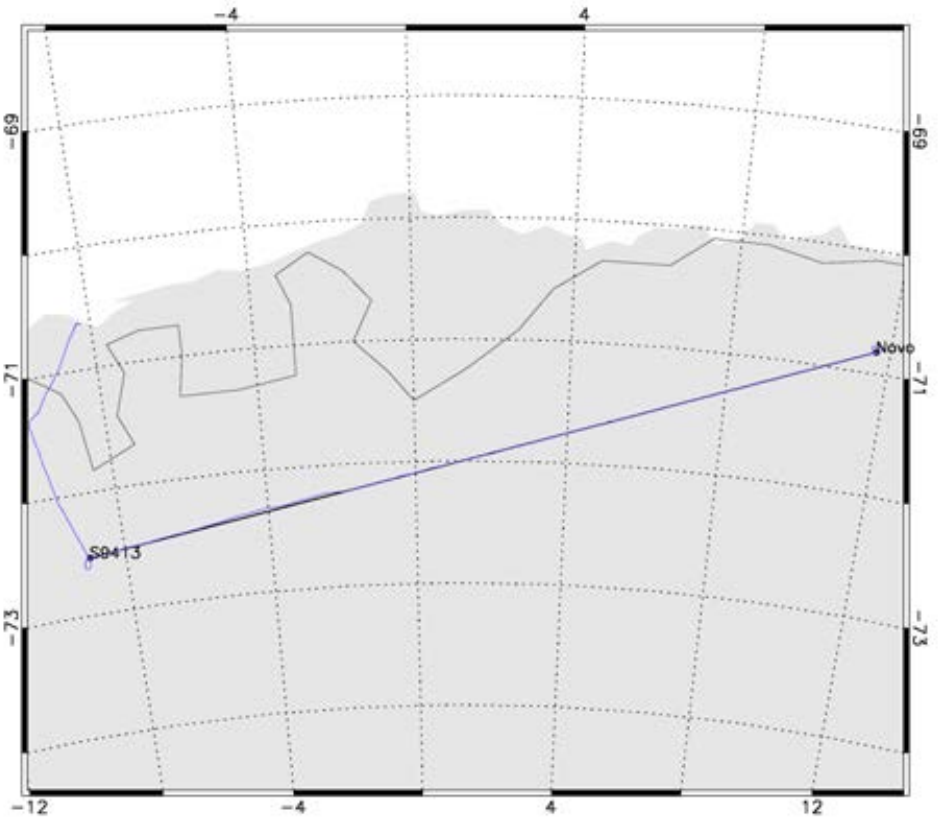


Figure A.2.: Overview of flight activity on 22nd December 2008. Blue line shows GPS track, black lines are showing the planned profiles.

Table A.2.: Event log of flight at December 22nd.

Event	Time (UTC)	Description
1	20:27:19	start mission takeoff 10 minutes before (lat=70:43.7621S lon=008:33.1281W alt=+0922)
2	20:27:55	calibration asr (lat=70:43.7621S lon=008:33.1281W alt=+0932)
3	20:28:14	calibration asr2 (lat=70:43.7621S lon=008:33.1281W alt=+0907)
4	20:30:22	going up for als test (lat=70:43.7621S lon=008:33.1281W alt=+0926)
5	20:32:35	loosing signal at 1050 m (lat=70:43.7621S lon=008:33.1281W alt=+1128)
6	20:40:32	asiras lama2500_00 (Shelf ice) (lat=70:43.7621S lon=008:33.1281W alt=+1061)
7	20:43:07	change shots to 90 (lat=70:43.7621S lon=008:33.1281W alt=+1190)
8	20:45:28	changed shots als 113 (lat=71:21.4740S lon=009:55.7825W alt=+1225)
9	20:46:00	asiras stop (lat=71:21.4740S lon=009:55.7825W alt=+1216)
10	20:46:33	dml96 (lat=71:21.4740S lon=009:55.7825W alt=+1211)
11	20:46:41	asiras lama2500_01 (DML96 - DML97) (lat=71:21.4740S lon=009:55.7825W alt=+1211)

continued

Event	Time (UTC)	Description
12	21:04:22	dml97 (lat=72:04.0904S lon=009:33.2533W alt=+1346)
13	21:09:30	als Fenster wird enger (lat=72:12.9308S lon=009:22.8439W alt=+1407)
14	21:12:41	als signal nearly lost (lat=72:21.5700S lon=009:12.8035W alt=+1447)
15	21:13:35	going down to 300 m (lat=72:23.6992S lon=009:10.0405W alt=+1445)
16	21:13:52	asiras stop (lat=72:24.0394S lon=009:09.6069W alt=+1429)
17	21:15:56	increasing to 300 m (lat=72:29.0037S lon=009:04.2711W alt=+1272)
18	21:16:13	increasing to 600 m (lat=72:29.5618S lon=009:03.6606W alt=+1302)
19	21:16:26	als signal back (lat=72:29.9471S lon=009:03.2340W alt=+1328)
20	21:17:40	asiras lama2500_02 (600 m, S9413 - Novo) (lat=72:32.4242S lon=009:00.2861W alt=+1534)
21	21:17:51	S9413 (lat=72:33.5626S lon=008:59.0925W alt=+1612)
22	21:22:47	asiras stop (lat=72:33.3425S lon=009:06.9961W alt=+1542)
23	21:22:55	asiras lama2500_03 (600 m, S9413 - Novo) (lat=72:33.1899S lon=009:06.5601W alt=+1545)
24	21:24:33	S9413 (lat=72:32.3848S lon=008:55.9258W alt=+1552)
25	21:25:59	als signal weak (lat=72:32.1517S lon=008:48.2009W alt=+1619)
26	21:28:39	going down to 450 m (lat=72:31.5090S lon=008:31.0956W alt=+1657)
27	21:29:20	asiras stop (lat=72:31.3670S lon=008:27.4734W alt=+1633)
28	21:29:59	asiras lama2500_04 (450 m, S9413 - Novo) (lat=72:31.1496S lon=008:23.1949W alt=+1601)
29	21:30:15	450 m (lat=72:31.0782S lon=008:21.4420W alt=+1590)
30	21:30:47	420 m (lat=72:30.9540S lon=008:17.8909W alt=+1589)
31	21:39:16	going up to 600 m (lat=72:28.9876S lon=007:20.0483W alt=+1820)
32	21:39:27	asiras stop (lat=72:28.9414S lon=007:19.1480W alt=+1897)
33	21:39:49	asiras lama2500_05 (600 m, S9413 - Novo) (lat=72:28.8001S lon=007:17.1456W alt=+1912)
34	21:42:02	no more als signal (lat=72:28.1126S lon=007:01.9460W alt=+2048)
35	21:42:16	600m (lat=72:28.0754S lon=007:00.9372W alt=+2067)
36	22:22:32	als signal back (lat=72:24.4875S lon=005:36.9752W alt=+1482)
37	22:26:23	crevasses (lat=72:24.4875S lon=005:36.9752W alt=+1325)
38	22:29:57	crevasses (lat=72:24.4875S lon=005:36.9752W alt=+1355)
39	22:35:18	crossing mountain (going up) (lat=72:08.7937S lon=000:43.2198W alt=+1413)
40	22:38:14	blue ice (lat=72:07.1982S lon=000:25.3333W alt=+1517)
41	22:39:15	mountain (lat=72:06.8157S lon=000:19.0261W alt=+1491)
42	22:40:39	asiras stop (lat=72:06.4187S lon=000:09.9434W alt=+1535)
43	22:42:08	asiras lama2500_06 (600 m, S9413 - Novo) (lat=72:05.8236S lon=000:02.6105W alt=+1699)
44	22:50:54	als signal weak (lat=72:01.3645S lon=000:54.7960E alt=+1851)
45	22:55:43	als signal nearly gone (lat=71:58.8836S lon=001:28.6658E alt=+1879)
46	22:57:48	crevasses (lat=71:57.7551S lon=001:41.5706E alt=+1909)
47	22:59:59	crevasses (lat=71:56.3742S lon=001:55.5758E alt=+1966)
48	23:05:17	als signal gone (lat=71:53.3762S lon=002:33.3921E alt=+1838)
49	23:07:08	blueice (lat=71:52.3602S lon=002:45.6364E alt=+1834)
50	23:07:42	mountain (lat=71:52.0191S lon=002:49.3488E alt=+1854)
51	23:11:57	crevasses (lat=71:49.5776S lon=003:15.5565E alt=+2015)
52	23:41:34	als signal is coming back (lat=71:37.0772S lon=005:21.2171E alt=+1901)
53	23:49:02	als ok (lat=71:37.0772S lon=005:21.2171E alt=+1625)
54	23:50:55	mountain (lat=71:37.0772S lon=005:21.2171E alt=+1652)

continued

Event	Time (UTC)	Description
55	00:02:45	crevasses (lat=71:11.8379S lon=008:57.9173E alt=+1624)
56	00:29:12	blue ice (lat=70:50.4297S lon=011:33.1637E alt=+1269)
57	00:30:17	novo runway (lat=70:49.7312S lon=011:40.5492E alt=+1163)
58	00:30:31	asiras stop (lat=70:49.6543S lon=011:41.2970E alt=+1166)
59	00:30:39	close rollerdoors (lat=70:49.4710S lon=011:43.2659E alt=+1175)
60	00:30:59	calibration asr (lat=70:49.3161S lon=011:44.3379E alt=+1161)
61	00:35:59	landing (lat=70:47.4945S lon=011:45.3801E alt=+0881)

A.3. CryoVE08/09-Antarctica - December 25th

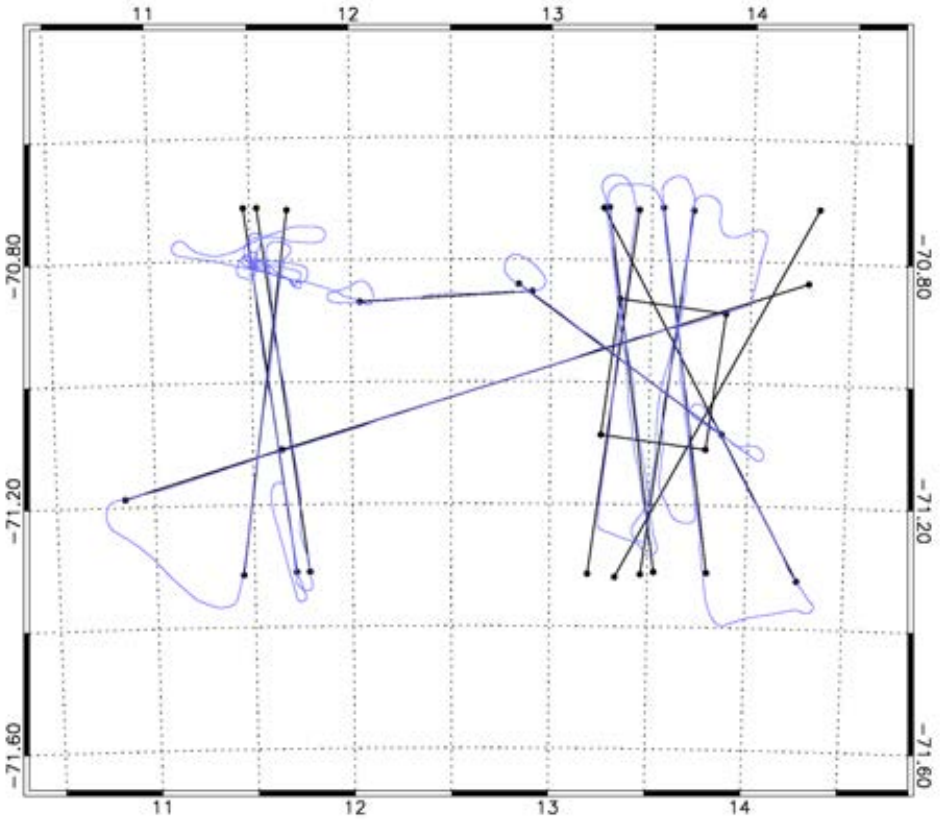


Figure A.3.: Overview of flight activity on 25th December 2008. Blue line shows GPS track, black lines are showing the planned profiles.

Table A.3.: Event log of flight at December 25th.

Event	Time (UTC)	Description
1	15:34:14	take off (lat=70:49.5204S lon=011:38.0740E alt=+0572)
2	15:38:33	calibration asr(lat=70:47.9374S lon=011:18.0083E alt=+1145)
3	15:39:02	calibration asr2 (lat=70:47.7969S lon=011:15.6248E alt=+1208)
4	15:54:47	asiras lama2500_01 (600 m, Novo RW) (lat=70:49.6296S lon=011:39.4869E alt=+0833)
5	15:55:15	cr (lat=70:49.9889S lon=011:42.8582E alt=+0851)
6	15:55:59	asiras stop (lat=70:49.8549S lon=011:46.8022E alt=+0812)
7	16:00:25	asiras lama2500_03 (300 m, Novo RW) (lat=70:48.3803S lon=011:26.5510E alt=+0845)
8	16:01:48	ast stop (lat=70:49.6547S lon=011:30.9330E alt=+0863)
9	16:04:32	asiras lama2500_03 (300 m, Novo RW) (lat=70:49.1246S lon=011:34.3253E alt=+0850)
10	16:05:36	cr (lat=70:49.8396S lon=011:41.4484E alt=+0821)
11	16:06:01	asiras stop (lat=70:50.0249S lon=011:43.9519E alt=+0811)

continued

Event	Time (UTC)	Description
12	16:07:59	rfd 3000, rfn 151Shots (lat=70:48.3627S lon=011:34.8069E alt=+0837)
13	16:10:12	asiras lama2500_04 (300 m, Novo RW) (lat=70:48.8706S lon=011:31.8806E alt=+0827)
14	16:11:32	cr (lat=70:49.8670S lon=011:41.8151E alt=+0844)
15	16:16:03	asiras stop (lat=70:51.0271S lon=012:06.3880E alt=+0678)
16	16:19:12	asiras lama2500_05 (300 m, U20 - P13) (lat=70:52.2665S lon=011:56.3993E alt=+0794)
17	16:20:17	u20 (lat=70:52.2281S lon=012:04.7669E alt=+0761)
18	16:20:49	schlechtes als signal (lat=70:52.0994S lon=012:09.3140E alt=+0696)
19	16:22:43	wolken (lat=70:51.7318S lon=012:21.4713E alt=+0726)
20	16:23:36	asiras stop (lat=70:51.4547S lon=012:27.0781E alt=+0961)
21	16:24:44	asiras lama2500_06 (600 m, P13-U14) (lat=70:51.4178S lon=012:34.5445E alt=+1081)
22	16:27:41	p13 (lat=70:51.0642S lon=012:55.0349E alt=+1093)
23	16:27:55	asiras stop (lat=70:51.0088S lon=012:56.3732E alt=+1113)
24	16:28:25	left turn 1000ft (lat=70:49.8410S lon=012:58.1526E alt=+1100)
25	16:31:40	2000ft (lat=70:49.9433S lon=012:47.8898E alt=+1048)
26	16:31:55	asiras lama2500_07 (600 m, U14-U08) (lat=70:50.2539S lon=012:49.3509E alt=+1065)
27	16:32:17	U14 (lat=70:50.7963S lon=012:51.9774E alt=+1099)
28	16:34:54	kein als signal (lat=70:53.6493S lon=013:04.1408E alt=+1210)
29	16:39:12	CR (lat=70:58.4355S lon=013:23.8356E alt=+1304)
30	16:45:30	u08 (lat=71:05.7685S lon=013:55.1145E alt=+1489)
31	16:45:38	asiras stop (lat=71:05.8980S lon=013:55.6343E alt=+1496)
32	16:52:58	asiras lama2500_08 (300 m, U08-E21) (lat=71:04.3045S lon=013:50.3292E alt=+1104)
33	16:53:10	300m (lat=71:04.4904S lon=013:50.6304E alt=+1111)
34	16:53:31	u081 (lat=71:05.5814S lon=013:52.4257E alt=+1156)
35	17:00:04	crevasses (lat=71:16.6659S lon=014:11.2288E alt=+1505)
36	17:01:54	E21 (lat=71:19.5136S lon=014:16.1824E alt=+1641)
37	17:02:05	asiras stop (lat=71:19.7224S lon=014:16.6465E alt=+1644)
38	17:09:37	asiras lama2500_09 (300 m, CY31-CY32) (lat=71:19.3567S lon=013:47.2834E alt=+1474)
39	17:10:02	cy31 (lat=71:17.8447S lon=013:46.5817E alt=+1449)
40	17:19:46	cr (lat=70:55.6075S lon=013:38.5027E alt=+1027)
41	17:20:19	als stop (lat=70:54.3071S lon=013:37.8677E alt=+0997)
42	17:20:36	als start (lat=70:53.7427S lon=013:37.6388E alt=+0960)
43	17:22:54	als off (lat=70:48.1067S lon=013:35.4286E alt=+0852)
44	17:25:06	cy32 (lat=70:42.4846S lon=013:33.2851E alt=+0724)
45	17:25:19	asiras stop (lat=70:42.0443S lon=013:33.1406E alt=+0720)
46	17:28:56	asiras lama2500_10 (300 m, CY22-CY21) (lat=70:43.5478S lon=013:42.2352E alt=+0782)
47	17:43:09	asiras stop (lat=71:11.1323S lon=013:30.2553E alt=+1123)
48	17:43:29	als rfn 109, rfs218000, rfd 4000 (lat=71:13.0756S lon=013:27.6876E alt=+1201)
49	17:47:28	asiras lama2500_11 (300 m, CY41-CY42) (lat=71:12.7830S lon=013:29.2613E alt=+1116)
50	17:51:18	als off (lat=71:04.6796S lon=013:24.8646E alt=+1043)

continued

Event	Time (UTC)	Description
51	17:54:52	als rfs 226000, rfn 113, rfd 4000 (lat=70:56.2050S lon=013:21.6089E alt=+0960)
52	18:02:09	cy41 (lat=70:41.5461S lon=013:15.5382E alt=+0876)
53	18:02:36	asiras stop (lat=70:41.4459S lon=013:15.4138E alt=+0890)
54	18:03:39	als rfs 224000 (lat=70:39.6726S lon=013:18.0224E alt=+0919)
55	18:06:11	asiras lama2500_12 (300 m, CY22-CY22) (lat=70:43.6394S lon=013:25.0962E alt=+0643)
56	18:18:04	since rfs 224000 als works fine (lat=71:06.9892S lon=013:17.0782E alt=+1067)
57	18:21:54	asiras stop (lat=71:13.7591S lon=013:14.6114E alt=+1240)
58	18:23:29	loosing als signal at 550 m (lat=71:15.2804S lon=013:21.7744E alt=+1540)
59	18:27:23	asiras lama2500_13 (300 m, CY42-CY41) (lat=71:12.3464S lon=013:30.4260E alt=+1164)
60	18:33:59	cr (lat=70:57.5933S lon=013:23.4093E alt=+0990)
61	18:40:48	cy41 (lat=70:42.1131S lon=013:16.7983E alt=+0824)
62	18:41:20	asiras stop (lat=70:41.7461S lon=013:16.8359E alt=+0857)
63	18:44:24	asiras lama2500_14 (300 m, CY32-CY31) (lat=70:41.9680S lon=013:32.3796E alt=+0658)
64	18:44:57	cy32 (lat=70:43.3311S lon=013:33.3879E alt=+0701)
65	18:52:42	cr (lat=70:57.6190S lon=013:39.4155E alt=+1003)
66	19:00:24	asiras stop (lat=71:04.7354S lon=013:42.1784E alt=+1230)
67	19:02:09	asiras lama2500_15 (300 m, CY11-CY12) (lat=71:04.7354S lon=013:42.1784E alt=+1188)
68	19:03:25	cy12 (lat=71:04.7354S lon=013:42.1784E alt=+1127)
69	19:14:41	cy11 (lat=71:04.7354S lon=013:42.1784E alt=+0742)
70	19:15:07	asiras stop (lat=71:04.7354S lon=013:42.1784E alt=+0742)
71	19:24:34	asiras lama2500_16 (300 m, WP2-WP1) (lat=71:04.7354S lon=013:42.1784E alt=+0977)
72	19:24:41	WP2 (lat=71:04.7354S lon=013:42.1784E alt=+0985)
73	19:36:16	crevasses (lat=71:00.4313S lon=012:40.7856E alt=+1044)
74	19:46:35	F33 (lat=71:06.8385S lon=011:37.4909E alt=+1306)
75	19:54:21	WP1 (lat=71:11.2406S lon=010:48.9770E alt=+1576)
76	19:54:33	asiras stop (lat=71:11.3072S lon=010:47.9865E alt=+1573)
77	19:57:10	climb to 500m (lat=71:15.5931S lon=010:53.4402E alt=+1774)
78	19:57:51	als loosing signal at 500m (lat=71:16.7807S lon=010:57.9743E alt=+1722)
79	20:01:22	calibration asr (lat=71:21.6582S lon=011:15.1583E alt=+1749)
80	20:03:27	asiras lama2500_17 (300 m, CY62-CY61) (lat=71:20.4405S lon=011:25.1016E alt=+1680)
81	20:04:22	cy62 (lat=71:17.9067S lon=011:26.7263E alt=+1596)
82	20:17:51	crossing runway (lat=70:49.4825S lon=011:39.2393E alt=+0843)
84	20:18:30	asiras stop (lat=70:48.1872S lon=011:40.0697E alt=+0803)
85	20:21:28	cy51 (lat=70:48.2122S lon=011:35.2330E alt=+0797)
86	20:21:41	asiras lama2500_18 (300 m, CY51-CY52) (lat=70:48.7110S lon=011:35.4468E alt=+0851)
88	20:37:11	cy52 (lat=71:01.6895S lon=011:40.4264E alt=+1645)
89	20:37:26	asiras stop (lat=71:01.6895S lon=011:40.4264E alt=+1659)
90	20:38:59	asiras lama2500_19 (300 m, CY71-CY72) (lat=71:01.6895S lon=011:40.4264E alt=+1649)
91	20:39:04	cy71 (lat=71:01.6895S lon=011:40.4264E alt=+1623)

continued

Event	Time (UTC)	Description
92	20:47:45	asiras stop (lat=71:01.6895S lon=011:40.4264E alt=+1597)
93	20:50:29	asiras lama2500_20 (300 m, repeat track CY71-CY72) (lat=71:01.6895S lon=011:40.4264E alt=+1600)
94	20:51:07	cy71 (lat=71:01.6895S lon=011:40.4264E alt=+1534)
95	20:53:06	als datei groesser als 650MB abbruch der datenerfassung (lat=71:01.6895S lon=011:40.4264E alt=+1444)
96	21:06:08	asiras stop (lat=70:46.1472S lon=011:29.7844E alt=+0685)
97	21:06:53	cy72 (lat=70:45.6434S lon=011:33.2858E alt=+0567)
98	21:08:55	asiras lama2500_21 (300 m, Novo runway) (lat=70:48.9409S lon=011:32.2346E alt=+0842)
99	21:09:36	runway start (lat=70:49.2750S lon=011:35.6661E alt=+0895)
100	21:10:23	runway end (lat=70:49.7437S lon=011:40.2654E alt=+0901)
101	21:10:48	cr (lat=70:49.9809S lon=011:42.7334E alt=+0903)
102	21:11:44	asiras stop (lat=70:50.5679S lon=011:43.2376E alt=+0847)
103	21:16:25	asiras lama2500_22 (300 m, Novo runway) (lat=70:48.8353S lon=011:31.4862E alt=+0851)
104	21:17:14	runway start (lat=70:49.3134S lon=011:36.0972E alt=+0875)
105	21:18:13	runway end (lat=70:49.7594S lon=011:40.5529E alt=+0868)
106	21:18:26	cr (lat=70:49.8695S lon=011:41.7495E alt=+0852)
107	21:18:46	asiras stop (lat=70:50.1881S lon=011:43.7178E alt=+0844)
109	21:21:23	land (lat=70:48.1514S lon=011:31.6986E alt=+0731)

A.4. CryoVE08/09-Antarctica - December 27th

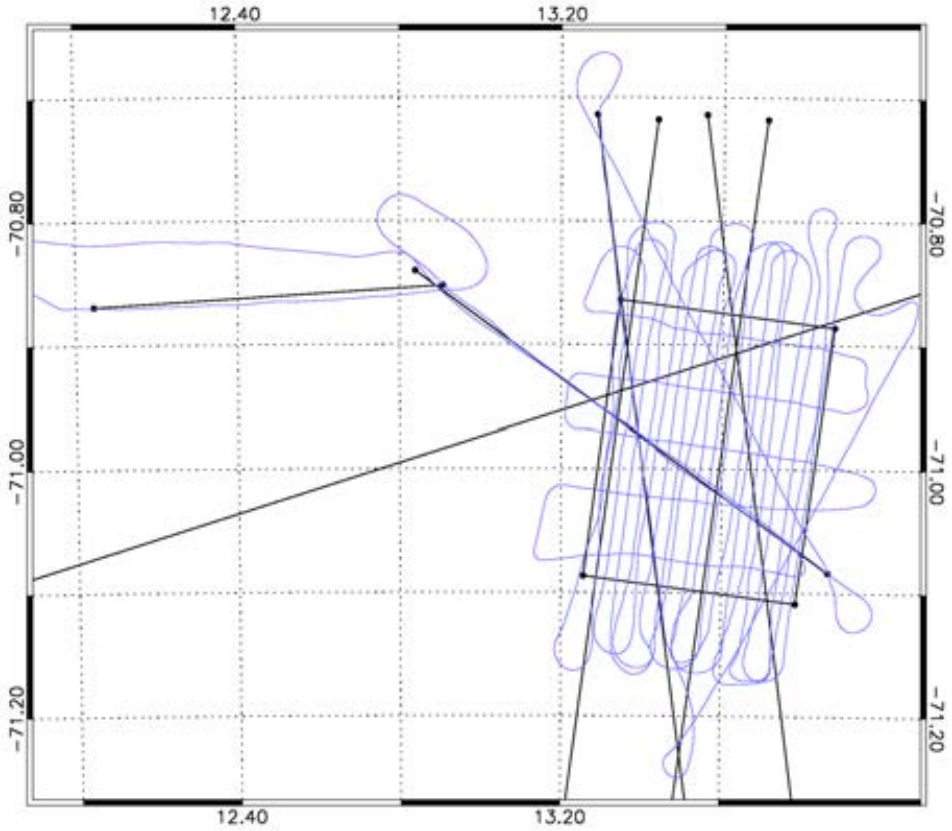


Figure A.4.: Overview of flight activity on 27th December 2008. Blue line shows GPS track, black lines are showing the planned profiles.

Table A.4.: Event log of flight at December 27th.

Event	Time (UTC)	Description
1	11:17:42	take off (lat=70:49.5469S lon=011:38.4071E alt=+0649)
2	11:20:25	open rollerdoors (lat=70:48.0407S lon=011:41.0701E alt=+1190)
3	11:21:06	asr calibration (lat=70:47.7522S lon=011:36.1861E alt=+1177)
4	11:29:47	asiras lama2500_00 (600 m, Novo runway CR) (lat=70:50.0780S lon=011:34.0895E alt=+1246)
4A	11:31:00	asiras stop
5	11:33:38	als 225000, 126, 3600 (lat=70:51.4904S lon=011:54.0598E alt=+1120)
6	11:35:33	asiras lama2500_01 (600 m, u20-p13) (lat=70:52.1828S lon=012:02.2937E alt=+1107)
8	11:35:55	u20 (lat=70:52.1849S lon=012:04.0656E alt=+1096)
9	11:39:19	wolken (lat=70:52.0645S lon=012:23.8022E alt=+1094)
10	11:39:32	600m (lat=70:52.0590S lon=012:24.6073E alt=+1102)
11	11:44:39	p13 (lat=70:51.3773S lon=012:55.9146E alt=+1196)
12	11:44:58	asiras stop (lat=70:51.3237S lon=012:57.7666E alt=+1218)

continued

Event	Time (UTC)	Description
13	11:50:50	asiras lama2500_02 (300 m, u14-u81) (lat=70:50.1613S lon=012:51.3664E alt=+0813)
14	11:51:00	u14 (lat=70:50.2630S lon=012:51.7789E alt=+0803)
15	11:57:58	cr (lat=70:58.4701S lon=013:24.4478E alt=+0973)
16	12:03:55	u81 (lat=71:05.2052S lon=013:52.7944E alt=+1122)
17	12:04:12	asiras stop (lat=71:05.4155S lon=013:53.7045E alt=+1126)
18	12:04:26	pilot change (lat=71:05.7629S lon=013:55.2509E alt=+1147)
19	12:06:22	als 224000, 113,4000 (lat=71:07.3242S lon=013:53.6128E alt=+1140)
20	12:07:56	als start (lat=71:05.5998S lon=013:52.5803E alt=+1159)
21	12:10:11	asiras lama2500_03 (300 m, u81-e22) (lat=71:05.5998S lon=013:52.5803E alt=+1051)
22	12:10:18	start profile 3 min ago (lat=71:05.5998S lon=013:52.5803E alt=+1075)
23	12:11:28	cr (lat=71:05.5998S lon=013:52.5803E alt=+1013)
24	12:14:50	clouds (lat=71:05.5998S lon=013:52.5803E alt=+0866)
25	12:19:17	e22 (lat=70:45.1472S lon=013:19.4896E alt=+0746)
26	12:19:31	asiras stop (lat=70:45.1472S lon=013:19.4896E alt=+0747)
27	12:22:38	asiras lama2500_04 (300 m, cy41-cy42) (lat=70:45.1472S lon=013:19.4896E alt=+0738)
28	12:23:11	cy41 (lat=70:45.1472S lon=013:19.4896E alt=+0736)
29	12:28:51	clouds (lat=70:45.1472S lon=013:19.4896E alt=+0918)
30	12:30:59	cr (lat=70:45.1472S lon=013:19.4896E alt=+0996)
31	12:35:49	cy42 (lat=70:45.1472S lon=013:19.4896E alt=+1134)
32	12:36:07	asiras stop (lat=70:45.1472S lon=013:19.4896E alt=+1133)
33	12:40:52	e11 (lat=70:45.1472S lon=013:19.4896E alt=+1155)
34	12:41:10	asiras lama2500_05 (300 m, e11-e22) (lat=70:45.1472S lon=013:19.4896E alt=+1165)
35	12:52:06	asiras stop (lat=70:45.1472S lon=013:19.4896E alt=+1025)
36	12:52:10	e12 (lat=70:45.1472S lon=013:19.4896E alt=+1006)
37	12:53:59	als off (lat=70:45.1472S lon=013:19.4896E alt=+0964)
38	12:54:46	als start (lat=70:45.1472S lon=013:19.4896E alt=+0975)
39	12:54:51	begin acquisition of grid (lat=70:45.1472S lon=013:19.4896E alt=+0976)
40	12:58:22	asiras lama2500_06 (300 m, g1-g2) (lat=70:45.1472S lon=013:19.4896E alt=+0943)
41	12:59:08	g1 (lat=70:45.1472S lon=013:19.4896E alt=+0952)
42	13:05:47	g2 (lat=70:45.1472S lon=013:19.4896E alt=+1147)
43	13:06:06	asiras stop (lat=70:45.1472S lon=013:19.4896E alt=+1146)
44	13:10:03	asiras lama2500_07 (300 m, g7-g8) (lat=70:45.1472S lon=013:19.4896E alt=+1126)
45	13:10:19	g7 (lat=70:45.1472S lon=013:19.4896E alt=+1109)
46	13:17:07	g8 (lat=70:45.1472S lon=013:19.4896E alt=+0939)
47	13:17:28	asiras stop (lat=70:45.1472S lon=013:19.4896E alt=+0939)
48	13:20:04	asiras lama2500_08 (300 m, g13-g14) (lat=70:45.1472S lon=013:19.4896E alt=+0890)
49	13:21:00	g13 (lat=70:45.1472S lon=013:19.4896E alt=+0917)
50	13:21:15	clouds (lat=70:45.1472S lon=013:19.4896E alt=+0951)
51	13:27:56	g14 (lat=70:45.1472S lon=013:19.4896E alt=+1109)
52	13:28:20	asiras stop (lat=70:45.1472S lon=013:19.4896E alt=+1149)
53	13:32:39	g19 1 min ago (lat=70:45.1472S lon=013:19.4896E alt=+1100)

continued

Event	Time (UTC)	Description
54	13:32:51	asiras lama2500_09 (300 m, g19-g20) (lat=70:45.1472S lon=013:19.4896E alt=+1085)
55	13:39:14	g20 (lat=70:45.1472S lon=013:19.4896E alt=+0913)
56	13:39:31	asiras stop (lat=70:45.1472S lon=013:19.4896E alt=+0917)
57	13:42:23	asiras lama2500_10 (300 m, g25-g26) (lat=70:45.1472S lon=013:19.4896E alt=+0839)
58	13:44:00	g25 (lat=70:45.1472S lon=013:19.4896E alt=+0894)
59	13:50:48	g26 (lat=70:45.1472S lon=013:19.4896E alt=+1065)
60	13:51:01	asiras stop (lat=70:45.1472S lon=013:19.4896E alt=+1092)
61	13:54:28	asiras lama2500_11 (300 m, g31-g32) (lat=70:45.1472S lon=013:19.4896E alt=+1087)
62	13:55:32	g31 (lat=70:45.1472S lon=013:19.4896E alt=+1051)
63	14:02:11	g32 (lat=70:45.1472S lon=013:19.4896E alt=+0893)
64	14:02:31	asiras stop (lat=70:45.1472S lon=013:19.4896E alt=+0892)
65	14:05:41	asiras lama2500_12 (300 m, g37-g38) (lat=70:45.1472S lon=013:19.4896E alt=+0792)
66	14:06:55	g37 (lat=70:45.1472S lon=013:19.4896E alt=+0842)
67	14:13:32	g38 (lat=70:45.1472S lon=013:19.4896E alt=+1059)
68	14:13:48	asiras stop (lat=70:45.1472S lon=013:19.4896E alt=+1064)
69	14:17:28	asiras lama2500_13 (300 m, g39-g40) (lat=70:45.1472S lon=013:19.4896E alt=+1068)
70	14:18:21	g39 (lat=70:45.1472S lon=013:19.4896E alt=+1044)
71	14:25:17	g40 (lat=70:45.1472S lon=013:19.4896E alt=+0862)
72	14:25:35	asiras stop (lat=70:45.1472S lon=013:19.4896E alt=+0841)
73	14:27:57	asiras lama2500_14 (300 m, g33-g34) (lat=70:45.1472S lon=013:19.4896E alt=+0781)
74	14:35:09	g34 (lat=70:45.1472S lon=013:19.4896E alt=+1056)
75	14:35:37	asiras stop (lat=70:45.1472S lon=013:19.4896E alt=+1085)
76	14:39:12	asiras lama2500_15 (300 m, g27-g28) (lat=70:45.1472S lon=013:19.4896E alt=+1107)
77	14:39:51	g27 (lat=70:45.1472S lon=013:19.4896E alt=+1024)
78	14:46:54	g28 (lat=70:45.1472S lon=013:19.4896E alt=+0879)
79	14:47:22	asiras stop (lat=70:45.1472S lon=013:19.4896E alt=+0876)
80	14:49:55	asiras lama2500_16 (300 m, g21-g22) (lat=70:45.1472S lon=013:19.4896E alt=+0866)
81	14:50:46	g21 (lat=70:45.1472S lon=013:19.4896E alt=+0927)
82	14:57:14	g22 (lat=70:45.1472S lon=013:19.4896E alt=+1088)
83	14:57:25	asiras stop (lat=70:45.1472S lon=013:19.4896E alt=+1112)
84	15:00:33	asiras lama2500_17 (300 m, g15-g16) (lat=70:45.1472S lon=013:19.4896E alt=+1129)
85	15:01:16	g15 (lat=70:45.1472S lon=013:19.4896E alt=+1090)
86	15:08:07	g16 (lat=70:45.1472S lon=013:19.4896E alt=+0933)
87	15:08:20	asiras stop (lat=70:45.1472S lon=013:19.4896E alt=+0920)
88	15:11:27	asiras lama2500_18 (300 m, g9-g10) (lat=70:45.1472S lon=013:19.4896E alt=+0907)
89	15:12:36	g9 (lat=70:45.1472S lon=013:19.4896E alt=+0954)
90	15:19:09	g10 (lat=70:45.1472S lon=013:19.4896E alt=+1123)
91	15:19:20	asiras stop (lat=70:45.1472S lon=013:19.4896E alt=+1126)

continued

Event	Time (UTC)	Description
92	15:22:25	asiras lama2500_19 (300 m, g3-g4) (lat=70:45.1472S lon=013:19.4896E alt=+1136)
93	15:23:46	g3 (lat=70:45.1472S lon=013:19.4896E alt=+1126)
94	15:30:14	g4 (lat=70:45.1472S lon=013:19.4896E alt=+0992)
95	15:30:22	asiras stop (lat=70:45.1472S lon=013:19.4896E alt=+0983)
96	15:33:46	asiras lama2500_20 (300 m, g5-g6) (lat=70:45.1472S lon=013:19.4896E alt=+0867)
97	15:36:07	g5 (lat=70:45.1472S lon=013:19.4896E alt=+0974)
98	15:44:41	g6 (lat=70:45.1472S lon=013:19.4896E alt=+1138)
99	15:44:49	asiras stop (lat=70:45.1472S lon=013:19.4896E alt=+1141)
100	15:48:03	asiras lama2500_21 (300 m, g11-g12) (lat=70:45.1472S lon=013:19.4896E alt=+1135)
101	15:49:00	g11 (lat=70:45.1472S lon=013:19.4896E alt=+1132)
102	15:55:37	g12 (lat=70:45.1472S lon=013:19.4896E alt=+0931)
103	15:55:57	asiras stop (lat=70:45.1472S lon=013:19.4896E alt=+0931)
104	15:58:37	asiras lama2500_22 (300 m, g17-g18) (lat=70:45.1472S lon=013:19.4896E alt=+0880)
105	15:59:35	g17 (lat=70:45.1472S lon=013:19.4896E alt=+0933)
106	16:06:37	g18 (lat=70:45.1472S lon=013:19.4896E alt=+1085)
107	16:06:56	asiras stop (lat=70:45.1472S lon=013:19.4896E alt=+1093)
108	16:09:58	asiras lama2500_23 (300 m, g23-g24) (lat=70:45.1472S lon=013:19.4896E alt=+1093)
109	16:11:10	g23 (lat=70:45.1472S lon=013:19.4896E alt=+1068)
110	16:17:52	g24 (lat=70:45.1472S lon=013:19.4896E alt=+0913)
111	16:18:08	asiras stop (lat=70:45.1472S lon=013:19.4896E alt=+0916)
112	16:21:13	asiras lama2500_24 (300 m, g29-g30) (lat=70:45.1472S lon=013:19.4896E alt=+0867)
113	16:21:22	g29 (lat=70:45.1472S lon=013:19.4896E alt=+0895)
114	16:27:57	g30 (lat=70:45.1472S lon=013:19.4896E alt=+1045)
115	16:28:09	asiras stop (lat=70:45.1472S lon=013:19.4896E alt=+1047)
116	16:30:59	asiras lama2500_25 (300 m, g35-g36) (lat=70:45.1472S lon=013:19.4896E alt=+1095)
117	16:31:57	g35 (lat=70:45.1472S lon=013:19.4896E alt=+1019)
118	16:32:26	crevasses (lat=70:45.1472S lon=013:19.4896E alt=+1037)
119	16:38:41	g36 (lat=70:45.1472S lon=013:19.4896E alt=+0861)
120	16:38:55	asiras stop (lat=70:45.1472S lon=013:19.4896E alt=+0848)
121	16:43:21	asiras lama2500_26 (300 m, Q2-Q1) (lat=70:45.1472S lon=013:19.4896E alt=+0887)
122	16:45:08	back on line (lat=70:45.1472S lon=013:19.4896E alt=+0931)
123	16:48:18	Q1 asiras stop (lat=70:45.1472S lon=013:19.4896E alt=+1007)
124	16:51:37	asiras lama2500_27 (300 m, Q4-Q3) (lat=70:45.1472S lon=013:19.4896E alt=+1020)
125	16:51:59	Q4 (lat=70:45.1472S lon=013:19.4896E alt=+1031)
126	16:56:37	Q3 (lat=70:45.1472S lon=013:19.4896E alt=+0910)
127	16:56:47	asiras stop (lat=70:45.1472S lon=013:19.4896E alt=+0908)
128	16:59:30	asiras lama2500_28 (300 m, Q6-Q5) (lat=70:45.1472S lon=013:19.4896E alt=+0967)
129	17:00:15	Q6 (lat=70:45.1472S lon=013:19.4896E alt=+0968)
131	17:05:30	Q5 (lat=70:45.1472S lon=013:19.4896E alt=+1063)

continued

Event	Time (UTC)	Description
132	17:05:43	asiras stop (lat=70:45.1472S lon=013:19.4896E alt=+1056)
133	17:09:38	asiras lama2500_29 (300 m, Q8-Q7) (lat=70:45.1472S lon=013:19.4896E alt=+1060)
135	17:14:02	Q7 (lat=70:45.1472S lon=013:19.4896E alt=+0987)
136	17:14:15	asiras stop (lat=70:45.1472S lon=013:19.4896E alt=+0995)
137	17:18:08	asiras lama2500_30 (300 m, Q10-Q9) (lat=70:45.1472S lon=013:19.4896E alt=+0981)
138	17:18:49	Q10 (lat=70:45.1472S lon=013:19.4896E alt=+1014)
139	17:23:50	Q9 (lat=70:45.1472S lon=013:19.4896E alt=+1114)
140	17:24:08	asiras stop (lat=70:45.1472S lon=013:19.4896E alt=+1138)
141	17:25:27	asiras lama2500_31 (300 m, u14-u081) (lat=70:45.1472S lon=013:19.4896E alt=+1086)
142	17:27:00	als run on 225000, 3600, 126 (lat=70:45.1472S lon=013:19.4896E alt=+1031)
143	17:29:12	cr (lat=70:45.1472S lon=013:19.4896E alt=+1012)
144	17:36:21	u8 (lat=70:45.1472S lon=013:19.4896E alt=+0842)
145	17:36:27	asiras stop (lat=70:45.1472S lon=013:19.4896E alt=+0828)
146	17:38:19	close roller doors (lat=70:45.1472S lon=013:19.4896E alt=+0677)
147	17:48:01	landing (lat=70:49.7442S lon=011:40.2138E alt=+0560)

A.5. CryoVE08/09-Antarctica - January 4th

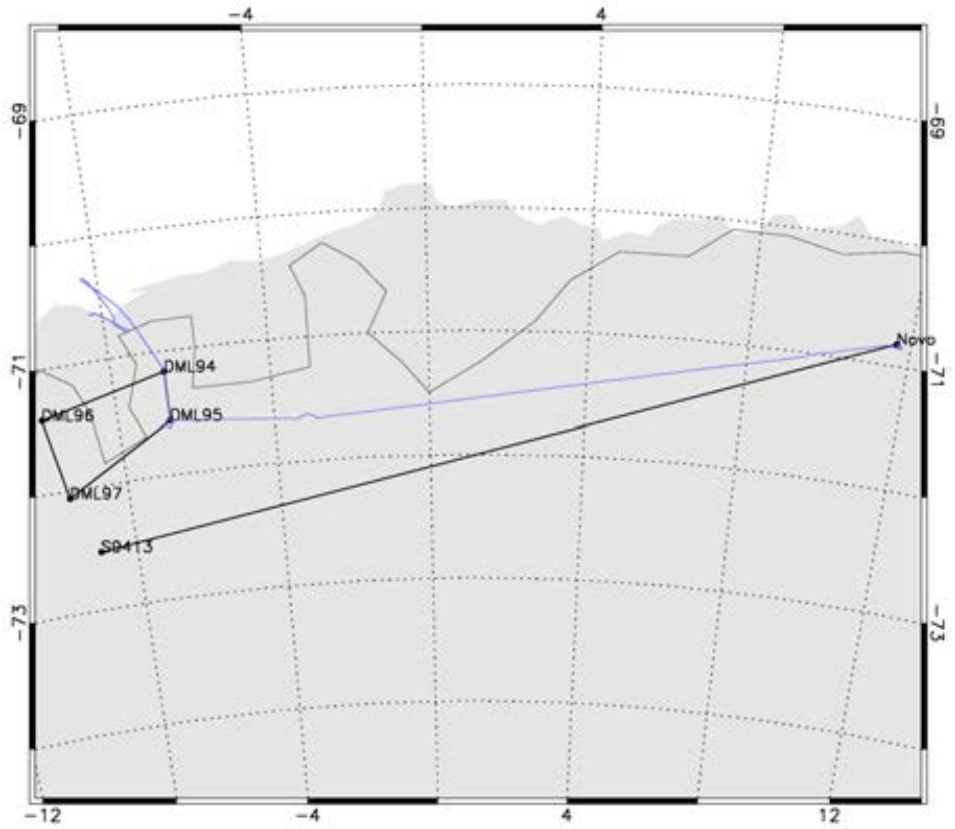


Figure A.5.: Overview of flight activity on 4th January 2009. Blue line shows GPS track, black lines are showing the planned profiles.

Table A.5.: Event log of flight at January 4th.

Event	Time (UTC)	Description
1	08:57:35	take off (lat=70:50.2701S lon=011:44.2452E alt=+0642)
1a	09:11	asiras ham5000_00 (2500 m, Novo to Sanae)
1b	09:12:30	asiras stop
1c	09:13	asiras ham5000_01 (2500 m, Novo to Sanae)
1d	09:15	asiras stop
2	09:16	asiras ham5000_02 (2500 m, Novo to Sanae) (lat=70:55.1751S lon=009:59.8769E alt=+3536)
3	09:17:14	video on (lat=70:55.1751S lon=009:40.4346E alt=+3536)
4	09:17:31	asiras stop (lat=70:55.1751S lon=009:38.6177E alt=+3536)
6	09:18:35	asiras ham5000_03 (2500 m, Novo to Sanae) (lat=70:55.1751S lon=009:31.0950E alt=+3536)
7	09:25:22	asiras stop (lat=71:06.0183S lon=008:40.4530E alt=+3540)
8	09:25:36	out of range (lat=71:06.1276S lon=008:38.9356E alt=+3537)
8a	09:26	asiras ham5000_04 (2500 m, Novo to Sanae)

continued

Event	Time (UTC)	Description
8b	09:27	asiras stop
9	09:29:58	asiras ham5000_05 (2500 m, Novo to Sanae) (lat=71:08.7213S lon=008:06.8983E alt=+3533)
10	09:30:24	asiras error (lat=71:08.9537S lon=008:03.3336E alt=+3535)
11	09:30:35	asiras stop (lat=71:09.0229S lon=008:02.3240E alt=+3537)
12	09:35:43	asiras reboot system (lat=71:12.1293S lon=007:18.4194E alt=+3537)
13	09:56:20	asiras ham5000_06 (2500 m, Novo to Sanae) (lat=71:12.4090S lon=007:13.9859E alt=+3519)
14	10:04:01	als on (lat=71:25.7589S lon=003:45.7788E alt=+3544)
15	10:04:26	asiras stop (lat=71:26.1074S lon=003:38.3554E alt=+3536)
16	10:07:05	asiras ham5000_07 (2500 m, Novo to Sanae) (lat=71:26.8204S lon=003:24.4862E alt=+3541)
16a	10:07	asiras stop
16b	10:07	asiras ham5000_08 (2500 m, Novo to Sanae)
17	10:18:15	als off (lat=71:26.8204S lon=003:24.4862E alt=+3546)
18	10:18:30	als on (lat=71:26.8204S lon=003:24.4862E alt=+3537)
19	10:21:15	asiras stop (asiras failed) (lat=71:26.8204S lon=003:24.4862E alt=+3544)
20	10:28:29	reboot asiras laptop (lat=71:34.6208S lon=000:29.4544E alt=+3525)
21	10:33:43	reboot asiras system (lat=71:36.0665S lon=000:12.6371W alt=+3548)
21a	09:26	asiras ham5000_09 (2500 m, Novo to Sanae)
21b	09:27	asiras stop du to failure
22	11:15:29	asiras lama2500_10 (300 m, DML95 to DML94) (lat=71:37.3767S lon=004:52.5622W alt=+1027)
23	11:17:01	als on (lat=71:37.3767S lon=004:52.5622W alt=+0915)
24	11:17:11	als 300m 225000 113 4000 (lat=71:37.3767S lon=004:52.5622W alt=+0905)
26	11:27:47	wolken (lat=71:37.3767S lon=004:52.5622W alt=+0871)
27	11:28:44	dml95 (lat=71:37.3767S lon=004:52.5622W alt=+0819)
29	11:39:27	dml94 (lat=71:37.3767S lon=004:52.5622W alt=+1023)
30	11:41:42	asiras stop (lat=71:37.3767S lon=004:52.5622W alt=+1012)
31	11:42:41	asiras lama2500_11 (420 m, ice shelf) (lat=71:37.3767S lon=004:52.5622W alt=+0981)
32	11:44:30	asiras stop (lat=71:37.3767S lon=004:52.5622W alt=+0944)
33	11:45:59	asiras lama2500_12 (420 m, ice shelf) (lat=71:37.3767S lon=004:52.5622W alt=+0832)
34	11:51:48	open water (lat=70:45.7297S lon=007:18.3142W alt=+0498)
35	11:59:58	open water (lat=70:45.7297S lon=007:51.3316W alt=+0509)
36	12:01:09	asiras stop (lat=70:45.7297S lon=007:57.5536W alt=+0526)
37	12:04:16	asiras calibration (lat=70:45.7297S lon=008:11.1892W alt=+1349)
38	12:09:09	asiras ham5000_13 (2200 m) (lat=70:45.7297S lon=008:14.6783W alt=+2232)
39	12:10:07	begin ham over open water (lat=70:24.5859S lon=008:08.4112W alt=+2253)
40	12:17:50	asiras stop (lat=70:41.1600S lon=007:42.7420W alt=+2231)
41	12:18:32	asiras calibration (lat=70:42.7483S lon=007:44.1821W alt=+2158)
42	12:18:40	asiras calibration (lat=70:43.0261S lon=007:44.5205W alt=+2135)

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Bibliography

Helm, V., S. Hendricks, S. Goebell, W. Rack, C. Haas, U. Nixdorf, and T. Boebel, Cryovex 2004 and 2005 (bob) data aquisition and final report, *Tech. Rep. 1.0*, Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany, 2006.